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PROTOTYPE OIL SHALE LEASING PROGRAM

COLORADO TRACT C-a
PRELIMINARY DEVELOPMENT PLAN

Submitted By
GULF OIL CORPORATION
and
STANDARD OIL COMPANY
(Indiana)

To The

State Director
Colorado State Office
Bureau of Land Management
U.S. Department of the Interior
Denver, Colorado

January, 1974

COPY No. 4

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1.0 INTRODUCTION

Gulf Oil Corporation and Standard Oil Company (Indiana), having submitted the winning bid for Colorado Lease Tract C-a, present herein their preliminary development plan pursuant to the terms of the oil shale lease sale.

This preliminary development plan expresses the general plan and intent of Gulf and Standard in developing Tract C-a. It is based on data presently available to the Companies, which in many cases are not yet adequate to allow firm plans to be made which will insure the most desirable method of development along with maximum feasible environmental protection. The Companies reserve the right, therefore, to revise the plan presented herein, based on additional data gained in the first three years of the lease, where such changes provide for:

(a) Improved project economics, operations and/or oil recovery, either without a serious increase in environmental impact, or with increased environmental effects which are justified by impartial cost/benefit analyses.

(b) Improved environmental protection, or equally effective environmental protection by more efficient means.

The entire content of this preliminary development plan is intended for public release and review. As work progresses, this plan will be revised and supplemented in accordance with new data. It is

the Companies' intent not only to comply with the lease terms requiring submittal of data for review by appropriate government agencies, but also to keep the public informed of their plans and progress through publication of a series of regular, or semi-regular, progress reports.

Questions and comments regarding this preliminary development plan may be submitted in writing to the attention of: Vice President, Fossil Fuels, Gulf Mineral Resources Co., 1780 South Bellaire Street, Denver, Colorado, 80222; and/or Manager, Energy Resource Planning, Standard Oil Company (Indiana), 200 East Randolph Drive, Chicago, Illinois, 60601.

1.1 PROJECT DEVELOPMENT PLANNING OBJECTIVES

The development of a viable project for extraction of shale oil on Tract C-a will require a very large number of engineering studies of mining and processing methods and equipment. A primary objective to the development plan will be, therefore, to conceive, coordinate and execute these engineering studies in a manner designed to enhance project economics and achieve the earliest feasible start-up date for project development. This objective is reinforced not only by the lease stipulations, but also by the contribution which a timely, viable project could make toward mitigating the U.S. energy shortage.

An equally important objective of the project development plan will be to incorporate environmental considerations into project engineering studies and decisions throughout the initial planning phase of the project.

Gulf and Standard currently believe that a minimum production rate of about 50,000 BPCD (barrels per calendar day) will be required for an economic project; this is a minimum development objective. However, it is the Companies' intent to increase this production rate, within operational, economic and environmental limits, to as large a production rate as feasible. This is presently thought to be 100,000-300,000 BPCD. Project development plans presented herein anticipate production rates of this magnitude.

Under terms of the lease, Gulf and Standard will submit for approval by the Mining Supervisor, at the earliest possible date, a plan describing the exploratory work proposed to be undertaken on the tract; and they will work with representatives of the appropriate governmental agencies to develop an acceptable Exploratory Plan. Detailed geological, engineering and environmental investigations of the tract and surrounding area will be conducted. Such studies are prerequisite to proper planning and development of the operation.

1.2 ENVIRONMENTAL PLANNING OBJECTIVES

The need for environmental protection and planning in oil shale development has been recognized by the U.S. Department of the Interior in the environmental stipulations which are part of the lease agreement for the Prototype Oil Shale Leasing Program. Gulf and Standard intend that the general requirements set forth in the lease's environmental stipulations be transformed into specific plans which will address all aspects of that document.

Gulf and Standard realize and appreciate the fact that the environment, viewed as a whole, is a complex ecological system in which subtle interrelationships are frequently disguised and may go undetected, resulting in misunderstanding of the importance of apparently minor components and processes. For this reason the Companies believe it imperative in the environmental baseline study that the total ecology be studied in an integrated, coordinated manner, rather than as a series of individual, unrelated components. This systematic approach will not only provide understanding of the basic ecological interrelationships important for successful environmental protection; it will also allow identification of those ecological parameters which are important to be monitored as indicators of environmental quality for the life of the lease.

1.3 REGIONAL PLANNING OBJECTIVES

Direct and indirect social and economic effects of oil shale development on the region are also important planning considerations. Considering the population sizes of communities surrounding the Piceance Creek Basin, development of even the prototype oil shale industry would have a significant influence on both the social and economic characteristics of the region. Coordinated regional, county and city planning will be needed to maximize the desirable social and economic effects caused by oil shale development in the area, and minimize the undesirable effects.

Socioeconomic data directly related to project development will be gathered by Gulf and Standard to aid projections and assessment of probable impacts resulting from a prototype oil shale industry in the area. Required temporary and permanent housing facilities will be estimated to aid private, local and regional government planning to accommodate the various stages of oil shale development.

Further, it is Gulf and Standard's intention to cooperate with, support and participate in, to the fullest extent afforded them, regional planning with the communities affected and with local, county, state and federal governmental agencies. Such planning and cooperation should ensure positive and beneficial effects to the region as a whole.

The benefits and/or objectives of this regional planning could be: (a) determination and coordination of land-use zoning; (b) balanced plans relating increased tax flows to the need for schools and public services; (c) development of a stable, well-rounded economy; and (d) assistance in providing for orderly, healthy community growth.

1.4 OVERALL PLAN: SCOPE AND OBJECTIVES

The overall scope and objectives of Gulf and Standard's preliminary development plan are set forth in detail in the subsequent sections of this document, which for convenience and understanding are presented in the following sequence:

Environmental Baseline Studies

Environmental Monitoring

Special Environmental Studies

Engineering and Development

Oil Shale Mining

Oil Shale Retorting and Upgrading

Off-Site Facilities

Project Schedules

This order of presentation is not intended to imply relative importance or timing of these aspects, or that planning and accomplishment of project development will be carried out as a number of separate functions.

To the contrary, it is Gulf and Standard's intention to carry out all of the above phases of the preliminary development plan in a coordinated, concurrent manner, as demonstrated in the final section, covering the project schedule.

Although various studies included in this preliminary development plan are described as Gulf and Standard projects, it is hoped that, where feasible, these would be cooperative projects conducted jointly with other oil shale operators.

Finally, Gulf and Standard are convinced that the optimization of all aspects of project development - engineering, operations, economics, timing, conservation and environmental protection - will ultimately be best accomplished by a planning philosophy which: (a) promotes adequate

research within each aspect; and (b) provides for the incorporation of new data resulting from this research into the project development plan.

research within each aspect; and (b) provides for the incorporation of new data resulting from this research into the project development plan.

ENVIRONMENTAL
BASELINE STUDIES

2.0 ENVIRONMENTAL BASELINE STUDIES

The rationale for the environmental baseline studies is to: (a) determine the physical, biological, human and socioeconomic parameters of the existing environment on and near Tract C-a; (b) monitor these parameters before, during and after development and production; (c) check these continually for compliance with provisions of the lease, so that all applicable federal, state and local environmental and pollution control requirements are met; (d) provide early detection of adverse effects that require correction; (e) identify factual criteria for any desirable revision or amendment of the stipulations and finally; (f) assist in socioeconomic studies and community planning of the region.

Baseline data will be collected to determine conditions existing prior to any development operations under the lease. Independent and non-profit organizations will be commissioned to make the baseline surveys and conduct monitoring operations impartially. The monitoring programs will be integrated into the final development plan.

2.1 PHYSICAL ENVIRONMENT

The entire system of living things discussed under the headings of biological, human and socioeconomic environments is supported totally by a physical environment which furnishes all the necessary nutrients and physical support for life. This supporting environment must be measured and understood in detail in order to predict the impact of changes.

2.1.1 GEOLOGY

Colorado Tract C-a is regionally located on the western flank of the Piceance Creek Basin about five miles east of Cathedral Bluffs. Beds within the tract generally strike to the north and dip basinward to the east-northeast at an average rate of about 300 feet per mile. A low relief anticlinal nose plunges southeast across the tract's southern portion. Three en echelon northwest-trending grabens parallel the axis of this structure, the most northerly of which bisects the tract. Within the boundaries of Tract C-a fault displacement ranges from a few feet to over 100 feet.

The Green River formation of Tertiary Eocene age comprises all surface rocks exposed within Tract C-a. The Evacuation Creek member covers the vast majority of the tract's surface. In several of the major drainages, the uppermost beds of the underlying Parachute Creek member are exposed in the valley walls. It is this member which contains the main oil shale interval discussed in detail below. Underlying the Parachute Creek member are the Garden Gulch and Douglas Creek members.

The main oil shale interval of the Parachute Creek member is generally defined as its top by the top of the Mahogany Zone or "A Groove", an excellent electric log resistivity marker throughout the Piceance Creek Basin, and at its base by the bottom of the "high resistivity zone" or top Garden Gulch member. This main oil shale interval lies at a depth of 100 feet or more within Tract C-a and regionally thickens northeastward across the tract, averaging about 900 feet. Although some rich shales occur immediately above and below the main oil shale interval, the thickest rich oil

shales are within the stratigraphic section between the two markers described above.

The main oil shale interval is not uniform in oil content from top to bottom but consists, rather, of alternating rich shale zones and relatively leaner shale zones. The areal persistence of these zones has long been recognized in the literature. In 1972, Cashion and Donnell (USGS Oil and Gas Investigations Chart OC 65) published a correlation chart which divides the main oil shale interval into several rich oil shale zones, separated by leaner oil shale, and designated Mahogany and R-6 to R-2 zones in descending order. These zones are present within Tract C-a.

Minor amounts of nahcolite, as isolated nodules rather than beds, are present in the Parachute Creek member within Tract C-a. Commercial quantities of gas and some oil have been produced from the Douglas Creek member of the Green River formation and the underlying Wasatch, Fort Union and Mesaverde formations elsewhere in the Piceance Creek Basin. The Fort Union and Mesaverde formations being evaluated in the Rio Blanco gas stimulation project underlie the entire tract at depths of 2,000 feet or more below the base of the main oil shale interval.

Detailed geologic, hydrologic and mining investigations of the tract and surrounding area will be coordinated to provide data necessary for the tract's optimum development and most economic recovery of its shale oil resources. Programs listed subsequently are considered of prime importance. (For further discussion, refer to Section 5.0, Engineering and Development.)

(a) Aerial Photography and Topographic Mapping - Construction of reliable base maps of necessary scale and detail will require new aerial photography, field surveying and photogrammetric methods. Color and color-infrared photos will be obtained for the surface geologic mapping described below and will also be useful for studies of soils, vegetation and surface drainage.

(b) Drilling Program - A detailed examination of all existing drill hole control within the tract will be conducted first and an evaluation made of the known definition and hydrologic characteristics of the main oil shale interval. On a preliminary plan basis, this will be followed by an "in-fill" drill hole program. In certain parts of the tract, additional drill holes may be required to obtain necessary hydrologic information. In addition, conventionally drilled holes may be located adjacent to fault zones to further define fault displacements, fault zone hydrologic conditions, the presence of possible fracture zones, and the underground minability of rich oil shale intervals offset by the faults.

(c) Surface Geologic Mapping - Surface geology will be mapped in detail. Examination of color air photos followed by field investigation will further define known fault systems and perhaps locate others which are currently unknown. Preknowledge of the exact locations and trends of faults is essential to the planning of mining operations, particularly those underground.

(d) Subsurface Geologic Mapping - Detailed structure, isopach and oil yield maps and cross sections of the Mahogany and other zones of minable interest will be constructed for optimum planning of mining operations.

2.1.2 TOPOGRAPHY

The topography of Tract C-a is characterized by northeast trending canyons and ridges. The slopes of the canyon walls are steep, the valley floors are narrow, and the ridges are broad and rounded. Altitudes within the tract range from 6,600 feet in Corral Gulch near the northeastern corner to about 7,000 feet on the ridges near the southwestern part of the tract.

There is considerable potential for gully erosion in the valleys of the Piceance Creek Basin due to the inherent instability of the alluvium which comprises the valley floors. The carving of new channels and formation of discontinuance gullies, which occurred over relatively short time periods (less than 100 years), have been observed in the Piceance Creek Basin. Therefore, the deceptively stable-looking valley floors may be sources of increased and potentially damaging sediment-loading of the basin's streams, and perhaps, the White River. To evaluate recent and current major gully erosion, surveys will be conducted to gain understanding of the historical occurrence of these events, to anticipate the natural likelihood of occurrence in the future, and to enable avoidance of practices which may contribute to such future events. Of particular significance in this analysis will be the estimated consequences of spent shale disposal in Corral Gulch, Box Elder Gulch, Water Gulch and Dry Fork to the west of the tract.

2.1.3 SOILS

The most basic information required for understanding of the ecology of any natural area is soils data. An inventory of the types,

physical and chemical characteristics, and distribution of the soils found on Tract C-a is required for ecological analyses and engineering studies necessary for planning construction of facilities. Engineering applications of soil information include road construction, water impoundment and diversion structures, and planning locations and design of various structures. Soils information is needed for ecological analyses to provide understanding of the myriad relationships involved between the soil, the plants growing in it and the many wildlife forms dependent on it.

Natural vegetation and, indirectly, wildlife in the basin could be significantly affected by changes in the soil mantle which occur over wide areas. Although most of the surface area of the Piceance Creek Basin is fairly stable, soils are generally shallow and poorly developed and are therefore more susceptible to damage than more mature soils. Erosion by wind or water is continuous in nature and efforts must be made to avoid accelerating such natural erosion.

At present there exists no detailed map of the soil types on Tract C-a. Broad soil associated maps have been prepared by the U. S. Department of Agriculture, Soil Conservation Service, but they may require supplemental data for application to specific problems.

Therefore, detailed soil surveys will be conducted on Tract C-a. Soil investigations will also be conducted on preliminary corridors considered for off-site facilities. This work will be undertaken in conjunction with the Soil Conservation Service.

The soils will be classified according to soil type and predominant soil associations. The distribution of the various soil types, depths,

zonation, physical and chemical characteristics will be prepared and correlated with the type and success of vegetation in the area, if possible. The depth of topsoil and subsoil over the area will be measured by field sampling with soil augers and by observations of soil profiles exposed along road cuts and erosion faces. The texture, organic-matter content, shrink-swell potential and other important soil quality factors will be estimated. The information obtained in these studies will be useful in designing reclamation programs for disturbed areas and locating off-site facilities to minimize erosion. Knowledge of the soils will also contribute to a better understanding of the factors affecting the abundance, diversity and distribution of vegetation in the lease area.

2.1.4 HYDROLOGY

Personnel of the U.S. Geological Survey, Water Resources Division, have compiled a very informative study of the hydrology of the Piceance Creek Basin in general as a contribution to the federal oil shale environmental impact statement. However, if insufficient data are available for predicting complete hydrology of Tract C-a, the existing data may be supplemented after consultations with the Water Resources personnel.

2.1.4.1 SURFACE WATERS

Principal drainages on the tract are Corral, Water and Box Elder Gulches and Dry Fork Creek. Southeast of the tract Stake Springs Draw is a major drainage, and to the north the first principal drainage is Big Duck

Creek. The general flow direction of all these drainages to the northeast. These ephemeral streams flow during the spring thaw and accompanying runoff period and, occasionally, following local heavy rains, with Yellow Creek receiving all surface runoff. No long-term precipitation or stream flow records exist for the lease area and vicinity. However, precipitation is estimated at 10 to 18 inches annually, with about half occurring as snow. Sediment loads during flash floods are especially heavy in the lower portions of the drainage way.

The baseline data gathering will establish pre-development conditions of surface stream water flows, their quality and quantity and the duration and temperature, sedimentation, etc., in all the five drainages named above and in Yellow Creek. The baseline data collection will include the following:

(a) Gauging Stations - Gauging stations for the continuous measurement of streamflow will be constructed on the major permanent drainages of Tract C-a. Additional gauging stations may be installed upstream from the lease area.

(b) Water Temperature - A thermograph will be installed at each gauging station to provide a continuous record of stream temperatures. The temperature sensor will be located at the deepest point in the channel cross section.

(c) Sediments - Sediment samples will be collected during runoff events. Since sediment concentrations vary with discharge, the sampling objective will be to collect samples over a range of flow conditions, both for individual storm events and longer-term flow periods. In this way, it

should be possible to characterize the sediment yield of the major drainages passing through the tract. Samples will be analysed for suspended solids.

A problem with sediment sampling by hand is that it is very difficult to be present at the sampling site during storm runoff events, particularly on the rising side of the hydrograph. Therefore it may be necessary to install pumping type samplers which pump a sample at predetermined intervals during runoff events. An alternative may be to use single-stage bottle samplers which collect a sample at preset stage intervals.

(d) Precipitation - Continuously recording precipitation gauges will be installed on the lease area and on the drainages above it. Since approximately 90 percent of the drainage area of the streams passing through the tract lie above the tract, gauges located on the tract will not necessarily be representative of the total volume of water falling on the drainage area or passing through the lease area. Recording gauges should, therefore, be included in the upper basin.

(e) Rainfall/Runoff Relationships - No long-term rainfall or runoff measurements are available on the C-a tract. This will be partially remedied by the instrumentation installed in the baseline program. However, for design purposes it will be necessary to determine rainfall frequency-duration-intensity relationships and the probable maximum storm for the area. This will be determined using historical data from the nearest long-term precipitation stations.

2.1.4.2 GROUND WATER

In the vicinity of Tract C-a, there are two aquifers in the oil shale zones; the upper aquifer is in the Mahogany Zone and above, and contains relatively good water with total dissolved solids of 950 ppm; the lower aquifer below the Mahogany Zone has poor quality water with total dissolved solids on the order of 2,900 ppm. The lower zone is the so-called "leached zone". Also, aquifers may be present in sands of the Douglas Creek member as potential sources of water underneath the tract.

The published USGS map of the potentiometric surface shows an eastward inclination of the top of the ground-water table at approximately 100 feet per mile. The western edge of the hydrologic basin coincides with Cathedral Bluffs; hence the recharge area above the mine site is west and southwest from the mine site for about five miles. The potentiometric surface shows a flattening of the gradient over a major part of the mine site area. Flow figures are recorded for some springs and water wells in the vicinity of the mine site.

The color aerial photography (Section 2.1.1) will provide detailed drainage configurations from Cathedral Bluffs to three miles below the tract. A detailed study of the potentiometric surface in the same area may be conducted, if needed, to supplement drill hole data. Springs and water wells in this area would be gauged, analyzed and systematically recorded prior to start of full scale mine development in order to establish a pre-mine understanding of the total ground-water situation. Establishment of the recharge area above the mine will allow correlation of average rainfall

information, evaporation rates, surface runoff rates and the rate of recharge into the ground-water table.

As per the terms of the lease, the lessee is required to conduct subsurface water testing to ascertain: (a) hydrologic conditions prior to development and (b) hydrologic changes throughout the life of the project. Complementing these requirements, a comprehensive hydrologic data collecting program will be needed to provide a basis for predicting mine dewatering rates and to develop an acceptable water disposal plan. In order to compile the basic information for these interpretations, hydrologic testing will be conducted in certain drill holes.

These drill holes will be used to monitor hydrologic characteristics of the aquifers. Data developed from these test bores will include the transmissivity, the storage coefficient, the direction of ground-water flow vertically and horizontally, and the lateral and vertical extent of the aquifers.

Each of the water-bearing zones identified will be isolated and pumped for designated periods. Following standard pumping test procedures, the pump discharge will be kept steady and will be measured to determine the rates of dewatering. Drawdown will be measured in each of the observation wells during the pumping tests.

2.1.5 WATER QUALITY

The chemical quality of the waters of the area will be an important indicator during development activities. Routine physical data such as flow, temperature and other water quality criteria will be obtained by

the installation of continuous monitoring equipment on permanent streams. Water samples will be collected and analyzed for organic and inorganic chemical constituents, including, without limitation, trace constituents subject to drinking water standards and water pollution controls. After the initial test of an observation well, water samples will be collected at six-month intervals and analyzed for evidence of trends in water quality as determined by comparing the samples with previous analyses. The records of all information obtained will be maintained.

The pattern of water sampling stations will include points above any possible discharges from the oil shale processing plant activities, near the point of discharge, and some distance downstream. Sampling stations will also be established below the confluence of major tributaries.

The White River will be sampled at points above and below the confluence of Yellow Creek. Yellow Creek will be sampled below the confluence of Corral Gulch. Samples will also be taken from the various intermittent streams within and around Tract C-a when water is available in them (see Figure 7).

2.1.6 SEISMICITY

An inventory of seismic activity in the Piceance Creek Basin will provide the baseline data necessary to assess probable impacts, if any, relating to plant construction and operation. This study will include a detailed evaluation of information from the Cecil H. Green Geophysical Observatory at Bergen Park, Colorado, and the Uinta Basin Observatory at Vernal, Utah. These laboratories have excellent data and records from

which it is possible to determine the seismic characteristics of the basin and to project long-term activity patterns.

2.1.7 TRACE ELEMENTS

Even under "pristine" conditions, soils, water, rocks and even biological materials contain significant amounts of trace elements, some of which may be of concern when abnormally high concentrations are encountered. Samples of soils, overburden and oil shale from the area will be periodically analyzed to determine the range of natural background concentrations of the following trace elements: arsenic, boron, cadmium, chromium, cobalt, copper, fluorine, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, sodium, vanadium and zinc. Broad-range emission spectrographic analyses will also be conducted on selected samples to determine if other trace elements are present in sufficient concentrations to warrant detailed study, or if any of the above elements can be dropped from the study. These baseline studies will document normal background levels and project possible impacts from leaching of raw shale, spent shale or overburden.

2.1.8 ARCHAEOLOGICAL AND SCENIC INVESTIGATIONS

According to the Final Environmental Impact Statement for the Prototype Oil Shale Leasing Program, Tract C-a does not have any recorded points of historic interest or sites of archaeological discovery. However, scientific and professional investigations will be conducted in order to discover whether any objects of antiquity, or of historic and prehistoric

interest (including, but not limited to, Indian ruins, pictographs, and other archaeological remains) exist prior to construction or mining of the tract.

The scenic condition will be recorded for mine, plant and disposal sites as well as for road, service corridors and off-site locations that might contain service facilities, so that a basis will be established on which to make periodic scenic reassessments.

2.1.9 METEOROLOGY AND AIR QUALITY

The meteorological baseline studies will provide observations necessary for an adequate understanding of the general atmospheric processes of the area and the degree of variability of each parameter. Air quality baseline information is desired on background levels of the following air contaminants: particulates, oxides of nitrogen, sulfur oxides, hydrocarbons and other pollutants. At least two full years of baseline data will be collected and analyzed during the development phase.

Once potential operational locations have been defined, these will be reduced to several preferred sites by a ranking technique. The meteorological and air quality measuring system, discussed later, can then be employed at these chosen locations and wherever else generation of air contaminants is likely. A more detailed description of the air quality and meteorology monitoring systems will be found in Section 3.1 and 3.2.

2.2 BIOLOGICAL ENVIRONMENT

A comprehensive understanding of the biological environment in the project area is necessary in order to assess the impact of the construction

and operation of the project on the ecosystem. Appropriate measures can then be employed to mitigate these impacts.

The interactions among the physical and biological components of the environment are quite complex and not fully understood at this time. The elements of time, seasonal change and biological variability are extremely important considerations in the field of applied ecology. These natural fluctuations must be understood in order to formulate meaningful conclusions and predictions. A detailed study will be required to establish the natural baseline conditions. This comprehensive survey will describe the basic composition and ecological processes of the area and provide useful information for environmental engineering and effective management of the biological resources.

2.2.1 NATURAL VEGETATION

A prerequisite to understanding of natural ecological relationships is an inventory of natural vegetation types and their distribution. Although general descriptions of the vegetation types which occur in the Piceance Creek Basin are available, there is no information on the details of plant community structure on Tract C-a.

Plants may be affected in a number of ways by normal mining operations. Direct mechanical damage is most obvious, but changes in animal populations could also affect grass and browse utilization, and gaseous and particulate emissions from the operations could make temporary or permanent alterations in natural vegetation. Any of these possibilities

is of a purely speculative nature unless and until a proper reconnaissance is made of the local flora and a program is set up to monitor the state of the flora through the time of operation.

For many years, federal and state resource management agencies, particularly the Bureau of Land Management, the Soil Conservation Service, the U.S. Forest Service and state wildlife agencies have been gathering information on semi-arid western ranges such as in the Piceance Creek Basin. However, most of that information was obtained specifically for application to single-use management programs, especially grazing. There may be differences between the types of range data required for management under specific use programs and those which are required to analyze ecological interrelationships. Therefore, available data needs to be supplemented for basic ecological analyses planned by Gulf and Standard.

A vegetation map of the area will be compiled to show the distribution of major plant communities and the relationships between topographic and soil features and patterns of vegetation. The color, infrared aerial photography supplemented by on-the-ground field surveys will document these patterns of vegetation and assess the general physiological conditions of the various plant communities. This will provide a basis for later comparison during the monitoring phase of studies.

2.2.2 WILDLIFE

General information on wildlife species expected to occur on Tract C-a is available in the ecological literature, especially in publications of the Colorado Division of Wildlife. Part of the baseline environmental

program may involve an inventory of the more important species, both spatially and temporally.

The distribution patterns of most wildlife species are directly related to habitat distribution, in particular, vegetation patterns. Therefore, the likelihood of occurrence of most wildlife species on Tract C-a will be qualitatively estimated on the basis of vegetation distribution. After general habitat patterns have been established, field sampling will be statistically designed to permit valid inferences of population sizes and distribution over the area. Field techniques employed will be those routinely used by wildlife managers and resource biologists, including both direct counts of individuals, and reliance on indices of various types. Some kinds of animals are obviously much more important to the ecosystem and to the economy than are others; effort will be expanded in proportion to the relative importance of the animals after the initial baseline study has been made.

Special considerations will be given to the study of rare and endangered species, such as black-footed ferret, prairie falcon, peregrine falcon, and certain types of fish, should any exist on Tract C-a.

With regard to migratory or resident mule deer, there are at least three ways in which development of Tract C-a could adversely affect their population patterns. First is the reduction of winter range area. Much of Tract C-a is vegetation with important browse species, including sagebrush, serviceberry, mountain mahogany and others. To the extent that any browse plants are removed, the amount of deer food will obviously be reduced. However, due to the comparatively small surface area expected to

be disturbed by the surface and/or underground mining operation and surface shale processing facilities at any given time, only a small fraction of the entire Piceance Creek Basin's available forage would be affected temporarily. The second area of possible adverse impact on mule deer population is impediment to annual migrations. Again, however, the relatively small land area to be occupied by facilities which could create this problem will be small. Finally, and probably of greatest concern, are the overall effects of increased human activity. Although difficult to foresee in detail, such problems as harassment of deer by feral dog packs, snowmobiling and poaching are recognized as potential human threats over which little control can be exercised. Probably the most effective advance deterrent to these activities is intensive community development planning to help avoid residential development of any type in the rural lease area.

The ecological interrelationships (including migratory patterns of birds and mannals) and plant and animal relationships will also be studied and semi-annual reports will be prepared.

A herd of 150 to 250 wild horses is known to be present in the Piceance Creek Basin. These animals are not an economic component of the ecosystem _per se_, but they are of great interest to citizens and are protected by federal law. It is not thought that operations on Tract C-a will affect the herd.

2.2.3 AQUATIC HABITAT

Studies of aquatic biology on the lease tract will include investigations of biota in perennial streams. The bulk of the aquatic biological

studies will include compilation of an inventory of natural surface water features, such as springs and seeps in the vicinity of the lease tract, and populations of the fish in them. Larger aquatic animals in these streams, such as reptiles and other amphibians, will also be noted. Studies of the fishes in these water will emphasize live trapping and release, rather than consumptive collections.

A great deal of information on aquatic biology of the area exists in already published literature. A comprehensive review of this information will be made and applied to development and implementation of this baseline study program.

2.2.4 INTEGRATION OF ECOLOGICAL DATA

The baseline ecological studies will indicate certain interrelationships between habitat types and the animal populations found in them. Interactions among the various animal populations and the stability of the ecosystem as a whole will also be examined. As a part of the overall ecological baseline information, the food habits and trophic relationships of the animal populations will be studied. Examination of stomach contents from selected animals of the different species and knowledge of their food preferences will contribute to this process. By reaching some understanding of the trophic relationships and patterns of energy flow through the ecosystem, interrelationships among the physical and biological components of the environment can be evaluated. Such an understanding will also provide a basis for predicting and evaluating the effects of external modifications of the environment.

2.3 HUMAN AND SOCIOECONOMIC ENVIRONMENT

A great deal of study has been made of the human environment of the area to be affected by oil shale development. The effects of oil shale development on local social and economic conditions in the region will be significant. On balance, the effects of such development should be positive, with new jobs created, and resulting economic benefits associated with increased monetary flows. However, there are possibilities for negative effects, if adequate support of the planning necessary to provide for increased services and institutions in the region is not obtained.

The current status of various social and economic parameters for the region's three counties, Rio Blanco, Garfield, and Mesa, has been researched and adequately documented. For the purpose of planning and providing specifically for future regional development, studies of projected labor force will be provided to appropriate planning groups.

Gulf and Standard realize and accept their responsibility, as industrial residents of the region, to aid, to the extent desired by local citizens, the community planning required for a stable, attractive, and permanent social and economic environment.

The local governments recognize that the problems of oil shale development go beyond any single operation or community, and rightly so. The interrelationships and interdependencies between local residents, industry and government are complex, and continued cooperative efforts will be needed for good planning that will find adequate solutions to keep northwest Colorado a good place to live during and after development of an oil shale industry.

We do not intend to develop a residential community on or near Tract C-a or otherwise contribute to the construction of facilities which could become modern counterparts of the historical company town. Gulf and Standard believe that adequate incentives will exist for expansion of existing communities and business centers as new industrial development progresses. However, we will cooperate with the residents of the region to support careful planning and resultant state or local legislation necessary to encourage expansion which is not haphazard, temporary or otherwise detrimental.

ENVIRONMENTAL MONITORING

3.0 ENVIRONMENTAL MONITORING

Once the baseline environmental conditions are described, continuing studies will be undertaken to monitor any changes in this baseline. Changes could occur because of natural fluctuations in the overall environmental system, because of activities associated with the construction and operation of the project or because of other activities in the area. Many environmental factors studied in the baseline program will not be expected to change, such as geology and soils; thus monitoring will not be required, although the baseline will be kept up-to-date by incorporating new discoveries or more accurate information. Factors such as air and water quality, and biological populations may vary considerably, and may require more careful monitoring.

The monitoring studies will be a continuation of and an addition to the baseline study program, but they will be conducted at a lower level of intensity, unless results indicate need for more intensive monitoring.

3.1 METEOROLOGY

A two-part program for describing meteorology of Colorado Tract C-a is planned: (a) an initial study for describing the general characteristics of air movement (particularly valley flow under stable conditions) and the distributions of stability, mixing depth and wind as a function of height, and (b) installing and operating ground- and tower-

mounted and other meteorology systems for continuous recording of weather parameters.

A meteorological tower at least 100 feet high will be erected to provide humidity, wind speed and wind direction at three levels: 100 feet above the surface of the plant site; approximately 30 feet above the surface of the plant site; and at ground level. The temperature will be measured at two levels: at least 100 feet above the surface of the plant site; and approximately 30 feet above the surface of the plant site. Records of all baseline data collection and monitoring programs will be maintained.

A recording rain/snowfall gauge and evaporation pan will provide data for runoff and leaching studies.

Upper-air meteorological studies will be made to adequately describe atmospheric stability and its effects on pollutant dispersion. Field campaigns will be conducted in which weather ballons are released over an eight- to ten-day period to study upper-air winds. These data will be correlated with data from the 100-foot meteorological tower to provide a profile of meteorological parameters through the lower few thousand feet of the atmosphere. At least four field campaigns, one in each season of the year, will be undertaken to determine the upper-air parameters. If these studies reveal potential problems with pollutants, more sophisticated techniques may be needed to define air flow in the area.

The broad-scale (synoptic) meteorology of the geographical area will be studied and analyzed. The on-site meteorological observations will be compared to determine whether local, small-scale conditions may be of importance in estimating contaminant dispersion in the project area.

3.2 AIR QUALITY

Instruments to measure the various indicators of air quality are well-known and of a high degree of sophistication. For any one air-quality parameter there is usually more than one commercial instrument available which is commonly recognized to be capable of providing reliable data. Equipment such as the following will be used to obtain data needed to judge air quality on the lease site at the present time and to monitor the air quality during operations:

(a) Continuous sulfur oxides analyzer to provide data on short-term concentrations.

(b) Sulfonation plates for 30-day cumulative totals of sulfur oxide at selected locations around the site.

(c) Continuous oxides of nitrogen analyzer for short-term concentrations.

(d) High-volume air sampler to obtain 24-hour samples of total suspended particulates.

(e) Dustfall jars for 30-day cumulative totals of coarse particulates at selected locations around the site.

(f) Other equipment which can measure such parameters as hydrocarbons, hydrogen sulfide, photochemical smog, etc., as initial data; and equipment that might be advised by the Mining Supervisor.

The most likely configuration for this array of instrumentation might be a self-contained equipment trailer. Although a single site would be most logical for pre-construction baseline data, use of a semi-portable trailer would not preclude alternate measurements at several locations during the monitoring phase of post-construction. Sulfonation plates and dustfall jars would, of course, be located at several selected sites from the beginning of the baseline study.

3.3 SURFACE HYDROLOGY

Monitoring of the surface hydrology on and about lease Tract C-a will continue throughout the life of the project, continuing the methods employed during the baseline studies. Gauging stations upstream and downstream of the operation will continue to be operated, although collection of data probably need not be so intensive as in the two-year baseline survey. These data will be integrated with the meteorological data,such as rainfall intensity and snowmelt conditions, as well as with water-quality data,such as sediment loading,in order to compare pre-development with post-development conditions.

3.4 GROUND WATER

Some of the drill holes used for pre-mine planning, subsurface geology and ground water mapping will be employed for monitoring stations. Data from these monitoring stations will record the influence of the entire operation on the potentiometric surface, on the downstream availability of ground water and on the chemical composition of the ground water.

3.5 WATER QUALITY

Sampling and chemical analysis of water from surface and ground water sources will be continued on a regular basis after completion of the baseline studies and commencement of construction. All stations will be sampled, although analyses will be made only for parameters found to be important in the baseline study.

3.6 TRACE ELEMENTS

Trace element concentrations in soils, water, overburden and shale will be measured, to the extent deemed necessary, during the construction and operation phases of the project. The scope and frequency of this monitoring will be determined after baseline data are evaluated.

3.7 VEGETATION

The transect and quadrat studies of representative vegetative communities will be continued for the monitoring program. Aerial infrared photography may also be conducted for comparison with baseline studies.

3.8 WILDLIFE

The baseline wildlife studies will be continued to monitor changes in the populations of representative animals. If any indicator organisms are identified in the baseline studies, they will be of particular interest in the monitoring program.

3.9 AQUATIC HABITAT

The physicochemical measurements made during the baseline studies will be continued as deemed necessary during the monitoring phase of the program, although scope and frequency of analyses will depend upon the data collected in the baseline studies. Frequency of sampling will probably be decreased. Acquisition of data on the distribution and abundance of vertebrate and invertebrate species will be maintained throughout the monitoring phase. Fish populations of the streams in the area will be monitored to estimate changes in species composition and numbers.

SPECIAL
ENVIRONMENTAL STUDIES

4.0 SPECIAL ENVIRONMENTAL STUDIES

If special studies are needed in answer to specific concerns, in order to establish key features of the development plan to be submitted under Section 10 of the lease, such studies could lead to periodic monitoring, but most will consist of a single study conducted in the baseline data gathering period.

4.1 HUMAN ENVIRONMENT

Once construction activities have begun, statistics will be gathered from time to time to determine employment trends as well as settlement and commuting patterns. These data would provide supplemental information needed by government agencies and others concerned with provisions of public service facilities, and with regional and local growth policies and goals.

The oil shale development will create both temporary and permanent employment; for example, the permanent work force required for a 100,000 barrel per day oil shale production on Tract C-a will depend on the mining and processing techniques finally selected, but in very round numbers might be estimated as follows:

Mining	1,400
Retorting-Upgrading	400
Total	1,800

This number of new jobs directly related to development of Tract C-a should result in a substantial number of peripheral jobs and in a sig-

nificant population increase. However, these employees can be from both local populations and newcomers; the Companies would give preference to hiring local qualified work force. The expected population increase has not been assessed at the present time.

The temporary labor force during initial years of pre-mine exploration and development on Tract C-a is expected to be in the range of 100-200 persons. During actual project construction for commercial operation the range in work force may be from 2,000 to 4,000.

4.2 SITE SELECTION

Both environmental and engineering studies must be evaluated in selecting sites for the processing facilities and solids storage areas, and in selecting corridors for pipelines, access roads and power transmission lines. Environmental inputs into this decision-making process may require investigations in the areas of land use, topography, geology, soils, climatology, hydrology and ecology.

4.2.1 LAND USE

Land use is a particularly important consideration in planning for off-site facilities such as pipelines and access roads. The processing facilities, raw shale storage areas and spent shale and overburden disposal areas will be located relatively close to the mine, and land-use patterns in the areas adjacent to Tract C-a do not appear to pose any substantial problems. However, other more distant off-site facilities may cross a variety of land uses.

The locations of the possible corridors for these facilities will be determined from detailed studies of maps and engineering requirements. Areas of obvious conflicts, such as historic or archaeological sites, wilderness areas and mining areas, will be avoided if feasible. Areas of probable development and urban expansion will be avoided wherever possible. Local planning groups and appropriate state and federal agencies will be kept apprised of plans and developments. The overall objective of these investigations will be to avoid or minimize adverse social and environmental consequences arising from construction of these facilities. This study will provide data for inclusion in the land-use baseline study, as well as for site selection.

4.2.2 TOPOGRAPHY

A topographic study will be conducted on the lease tract and the area surrounding it. Valleys, plateaus, creeks, gulches, mountains and general relief will be evaluated as they pertain to placement of the processing facilities, raw shale storage area and overburden and spent shale disposal areas. Slope and natural drainage features will be important considerations in this study. Similar studies will be made of the prime corridors for off-site facilities.

4.2.3 GEOLOGY

Geological investigations will be conducted in the vicinity of the lease tract to determine structural stability or other potential geological problems. Engineering aspects of soil geology will also be evaluated in the areas of the off-site corridors. Areas of probable structural instability

will be avoided. This will help to minimize the possibility of power outage or oil spills caused by structural damage.

4.2.4 SOILS

Soils in the vicinity of the lease tract and the off-site corridors will be surveyed and classified with respect to erodibility and stability. Erosion problems associated with existing roads, pipelines and utility lines in the area of study will be documented. Subsurface investigations will also be conducted in the vicinity of potential sites for the processing facilities and solids storage and disposal areas. These investigations will emphasize subsurface drainage characteristics and foundation stability.

4.2.5 CLIMATOLOGY

Weather and climatic factors will be considered in site selection, with special emphasis on the intensity, duration and seasonal distribution of precipitation. Dispersion of air pollutants will be another topic of special concern, and the micrometeorological data gathered in the baseline study will be an essential part of the source data.

4.3 OVERBURDEN AND SPENT SHALE RECLAMATION

Much of the waste rock and overburden excavated from either open pit or underground operations will be disposed of on the surface adjacent to the lease tract. More than 50 percent of the spent shale produced by the retorting operations will have to be disposed of on the surface. Gulf and Standard

recognize the problems associated with a disposal operation of this magnitude. The following program of reclamation research is designed to find ways to stabilize the surface of the disposal areas, prevent erosion and return the land to a useful and productive condition.

Assuming there are no physical and chemical limitations which cannot be corrected by natural weathering, fertilizing or surface treatments, vegetation could be established directly on these materials. Considerable research has already been done on spent shale similar to that to be produced by retorting operations presently contemplated by Gulf and Standard. These studies have shown that vegetation can be grown successfully on spent shale if suitable fertilization, irrigation and surface treatments are provided initially. Successful reclamation has also been demonstrated on overburden (principally from coal mines) in several areas of northwestern Colorado. Local conditions may vary considerably, however, and the feasibility of successful reclamation of overburden and spent shale developed from Tract C-a must be determined.

Samples of overburden will be obtained from core drilling to be conducted on the site during 1974. Representative sample sections will be selected by a team of geologists and soil scientists. Spent shale samples may be obtained from existing operations in the area which use a similar retorting process, or from a pilot processing facility using shale from the lease tract.

Representative samples of overburden and spent shale will be analyzed for the following chemical characteristics:

- pH
- soluble salts
- available plant nutrients (nitrogen, phosphorus, potassium, iron, calcium, magnesium)
- organic matter
- cation exchange capacity
- base exchange capacity
- carbonates

Laboratory methods used in these analyses will be in accordance with standard soil testing procedures. If potential problems are indicated in these analyses, more detailed studies will be performed to evaluate the concentrations of these elements available to plants or leachable into water systems.

Leaching studies on spent shale will provide more valuable information for reclamation. For example, previous studies have shown that spent shale contains soluble salts in concentrations that are deleterious to plant growth. Leaching reduces salt concentrations in the upper zones of the spent shale column to levels acceptable for plant growth. The manner and rate of leaching prior to planting may require further investigation for this particular site.

4.3.1 FIELD TESTING

Laboratory and growth chamber studies will be conducted simultaneously which will provide valuable information on the growth potentials of plants in

these substrate materials. The results and hypotheses derived from these studies must be verified and refined by on-site field testing under local climatic conditions.

The field studies will be designed to evaluate a number of variables and treatments which might include, for example:

(a) Effects of slope and aspect on plant growth;

(b) Optimum fertilization rates;

(c) Value of supplemental watering to improve seed germination and growth;

(d) Optimum seeding rates and species;

(e) Effects of leaching the substrate (naturally or artificially) and delaying plantings;

(f) Optimum time of year for planting; and

(g) Effectiveness of various methods of seedbed preparation.

4.3.2 GROWTH CHAMBER STUDIES

In some cases, growth chamber studies could be a valuable adjunct to field testing by providing a gross screening of the myriad variables found in nature. Separation of less important parameters from experimental designs would simplify field work and make field data easier to interpret. A number of growing seasons can be compressed into a single year, thus providing a powerful tool for speeding up revegetation research. For example, basic evaluation of candidate plant species, both commercial and native, can be undertaken on spent shale under climatic conditions (temperature, moisture,

light) found on the lease site. Discarding the most obviously unsuitable plant materials will greatly simplify field designs and allow the on-site testing to concentrate on those species most likely to be successful.

ENGINEERING
AND DEVELOPMENT

5.0 ENGINEERING AND DEVELOPMENT

It is Gulf and Standard's belief that engineering and development activities prior to opening a mine on Tract C-a should be much more extensive than normally undertaken. A large number of alternative routes and methods for commercial production are evident. These alternatives must be analyzed and evaluated in a search for the preferred initial mining and process schemes. For example, questions such as these must be resolved: whether to employ open pit, open pit-underground, or in situ extraction methods, or some combination of these methods; what type, or types, of retort to use; selection of upgrading process sequence; etc.

This section of the preliminary development plan presents highlights of a pre-mine program based on the above precepts. A number of the functions are covered in additional detail in other sections of the plan under headings to which these activities apply specifically.

5.1 MAPPING

Detailed maps of topography and drainage will be prepared covering Tract C-a and surrounding areas which may be directly affected by operations. Using these maps as a base, other maps will be compiled which show: surface geology, soil types, vegetation and land use.

Maps showing features of subsurface geology of the oil shale deposit also will be prepared as part of pre-mine development. Data shown on these maps will include: overburden thickness contours; thickness and structure of the alternating rich and lean oil shale zones; lateral variations

in oil yield; location and nature of other minerals associated with the oil shale; and hydrology of the subsurface formations.

5.2 DEVELOPMENT DRILLING

Drilling will be undertaken early in the pre-mine development period to acquire additional data needed to supplement information obtained from prior drilling programs. Objectives of this drilling will include the obtaining of: (a) thickness, extent and yield of oil from the formation; (b) location of water-bearing intervals, the quality and quantity of water present in these intervals, and estimated rates at which it would be produced in the course of oil shale mining; (c) the location and concentration of minerals, such as dawsonite and nahcolite, associated with the oil shale, and which may be of future commercial value; and (d) rock structure, strength and other data pertinent to design of mine workings.

Each of the proposed drill sites will be visited by company representatives, along with representatives of the governing federal agencies and site-work contractors. Actual well locations will be staked and acceptable access routes marked on the ground to make maximum use of the natural topography, achieve harmony with the landscape and cause minimum disturbance to the ecology. Proper safeguards will be taken during drilling operations to protect air and water quality in the area. Federal and state laws, regulations, and standards relating to air, water, land and noise pollution will be complied with. The drill holes will be properly plugged in accordance with instructions from the Mining Supervisor, once such holes are no longer required in the ground-water monitoring program.

5.3 HYDROLOGIC TESTING

Gulf and Standard will conduct subsurface water testing, in accordance with guidelines set by the Mining Supervisor, to ascertain (a) hydrologic conditions prior to development and (b) hydrologic changes throughout the life of the project. Complementing these requirements, a comprehensive hydrologic data collecting program will be needed to provide a basis for predicting mine dewatering rates and to develop an acceptable water disposal plan.

The Water Quality Standards for Colorado and any other regulation of the Colorado Water Quality Control Commission will govern the disposal of water produced during hydrologic testing. Should large quantities of water be encountered, it will be impounded and either allowed to evaporate or be disposed of as authorized by the appropriate agency. It is not anticipated that any additional road construction will be necessary to carry out the subsurface hydrologic testing, as the well-road network would be established during the drilling phase of the exploratory program.

5.4 SEISMIC STUDIES

Gulf and Standard may experiment with seismic surveys to determine if they can provide, in conjunction with drilling data, the location and extent of geologic features (such as subsurface rock continuity, severe faulting and folding) important to planning, location and design of mine workings and surface facilities.

5.5 MINING ENGINEERING AND STUDIES

Beginning with the existing body of oil shale mining data available, Gulf and Standard will undertake extensive mining and engineering studies. Although mining plans are presented herein for Tract C-a that are thought to be feasible, a major objective of these studies will be to develop improvements or alternatives to these mining plans that will enhance economic, operational, conservational or environmental aspects of oil shale mining. Pursuant to this effort, the Companies may find it advisable to conduct pilot mining on Tract C-a. There may be mining uncertainties such as dewatering problems, highwall stability, pillar strength, underground faulting and fracture patterns that may require full scale prototype testing to resolve.

5.6 PROCESSING ENGINEERING AND STUDIES

Numerous schemes for retorting oil shale exist in various stages of development. Two processes are presently under consideration for retorting on Tract C-a: (a) a hot solids direct contact process and (b) an internal combustion process similar to the gas combustion process invented by the Bureau of Mines but with innovations designed to overcome problems experienced in previous pilot plant operations. Other retorts may be piloted by Gulf and Standard depending on process developments before mine production begins. Prototype retort demonstration may be required before making a commitment to a full scale commercial plant.

Future experimental development work will be directed toward optimizing the upgrading system. A goal will be the elimination of coking as an upgrading process in favor of hydroprocessing. If hydroprocessing technology can be developed on an economic basis, more synthetic crude would be yielded from a given amount of shale; the weight of product now considered to be in the form of coke could then be converted into equivalent synthetic crude. If coking remains the preferred upgrading process, the coke might be utilized on-site for fuel or power generation, instead of being sold. Other studies would be made to optimize between on-site upgrading and final upgrading in a conventional refinery where finished products are produced. Upgrading alternatives range from little or no upgrading to complete and final refining at the site of shale processing.

5.7 WATER DEVELOPMENT

Gulf and Standard will conduct, early in the pre-mine development phase, additional studies of: (a) water requirements of mining, processing and spent shale disposal; (b) water expected from mining and pumping; (c) the usability and disposal of water from underground operations; and (d) the amount of water required from other surface or subsurface sources for on-site uses. Based on the results of these studies, an overall water management plan pertinent to Tract C-a will be developed. The Companies will move toward acquisition and development of additional water rights, if necessary.

5.8 SURFACE RIGHT ACQUISITION

Concurrent with the aforementioned pre-mine development activities, Gulf and Standard will carry out a program of surface right acquisition both on and off the tract as necessary for the operation.

OIL SHALE MINING

6.0 OIL SHALE MINING

Gulf and Standard have developed two alternate plans for mining Tract C-a. The first plan is a combination of surface mining where overburden is thin and underground mining where overburden is thick. This plan will provide maximum recovery of oil from the tract by using off-site surface area for disposal of waste materials. The second plan is a multi-level underground mine which removes selected zones of high grade shales from those portions of the tract with suitable geological characteristics.

Gulf and Standard believe that, based on the existing data, either plan is feasible for the tract. There are many factors to consider and final selection of either plan described herein, or of some other mining plan, will depend on obtaining more data from the tract, especially about faults and fracture patterns and the nature of aquifers in the oil shale zones. The mining plan that is eventually selected by Gulf and Standard must, of course, be approved by the Mining Supervisor before construction can begin.

Gulf and Standard envision that the initial commercial plant will be between 50,000 and 100,000 BPCD capacity. If the initial plant proves to be economically viable and environmentally acceptable, production would be expanded in stages to the maximum capacity that can be supported by the lease. In the case of underground mining this may be about 100,000 BPCD, but surface mining may reach 300,000 or more BPCD.

6.1 COMBINATION OPEN PIT-UNDERGROUND PLAN

This plan calls for open pit mining on the portions of Colorado Tract C-a where the overburden is relatively thin. Underground mining will be used where the overburden thickness or lease boundary limits the open pit method. Excavation of materials in the open pit may extend down to the bottom of Zone R-2 or below, and material removal by underground mining will be from selected oil shale zones reached horizontally by adits from the sides of the pit. Figure 1 is a general site plan for the combination scheme.

The initial mining plan would be designed for the extraction of oil shale at rates sufficient to produce 50,000 to 100,000 BPCD. With an oil shale richness of 25 to 30 GPT (gallons per ton) (blended), the retort feed requirement would be in the range of 90,000 to 180,000 tons of crushed oil shale per calendar day. In order to gain perspective on the mining-retorting operation (i.e., its size, logistics, waste disposal, etc.), the initial plan is assumed to extend over a 30-year period. Most of the details in the following description of the plan are based on this initial plan.

Oil shale deposits under Tract C-a exceed the requirements of the initial plan. Expansion beyond the initial rate would be undertaken as soon as environmental, operating and economic factors indicate that a larger operation is tenable and feasible. A first expansion would likely double or triple the size of the operation. Over the long term, the objective would be to maximize recovery of the oil shale under the tract in the most efficient manner, compatible with environmental considerations.

The initial plan is based realistically on current mining technology and on available proven equipment. Future technological developments and advancements in equipment design may result in improved techniques for both open pit and underground mining of oil shale. The mining plan most certainly would be modified to incorporate any such improvements which fit in with the long-term objective of the operation.

In the following text, the open pit and combined underground mining operations are discussed separately. Also discussed are the related plans for the secondary crushing plant, solids disposal, dewatering and reclamation.

6.1.1 OPEN PIT

Initial open pit mining is proposed to be located in the northwest portion of Tract C-a. Three main criteria were used in selecting this site for the commencement of mining operations:

(a) The site should require the minimum amount of time and effort to reach the designed ore output rate.

(b) The site should provide a desirable (low) ratio of overburden to oil shale.

(c) The site should be located favorably with respect to disposal areas.

Figure 2 shows the location of the open pit and its areal extent after removal of 90,000 tons of oil shale per day for 30 years. The pit is bordered by tract limits on the west and north and by increasing overburden ratios on the east and south.

For a premised 50,000 BPCD, 30-year operation, total retort feed of some one billion tons of oil shale will be required. In addition, over 400 million bank cubic yards of overburden and waste will have to be removed. Approximately 80 percent of retort feed and all of the overburden and waste will come from the open pit. After excavation of this material, the upper rim of the pit will encompass about one-sixth of the original surface area of the tract. The pit slope will be maintained for stability and safety. By the end of the 30-year period, the average depth of the pit (to the base of Zone R-4) will be about 1,000 feet below the original surface.

The open pit mining plan employs shovels and trucks in conjunction with strategically located primary crushers (in the pit) and conveyor belt systems. The sequence of operations involves drilling, blasting, loading, hauling, crushing and conveying. Although these operations may be cyclic in one area of the pit, the total mine operation requires them to be concurrent.

The overburden, waste and oil shale materials must be drilled and blasted for removal. All these materials have relatively similar geologic characteristics which pertain to fragmentation by blasting. Drilling will be accomplished by electric powered rotary drills. The blasting operation will utilize both ANFO (ammonium nitrate fuel oil) prills and slurries for explosives.

The primary crushing will be done in or adjacent to the pit where the excavated material, including overburden and waste, will be reduced to minus 8 inches. The number and location of the crusher stations will be coordinated with pit development; adequate standby crushing facilities will be provided.

Trucks hauling mined material from the pit and from the underground adits will dump directly into the crushers. After the material has passed through the primary crushers, an intermediate conveyor belt will direct it to a central point for conveying out of the pit.

6.1.2 UNDERGROUND MINING

The area designed for underground mining during the initial period lies east of the open pit. It is enclosed to the north and east by the lease boundaries and to the south by a major fault zone. Surface geology and core hole data available to date suggest an absence of major faulting in this area.

Underground operations will be initiated in the three upper-most richer intervals within the principal oil shale measure. In brief, the general characteristics of these intervals are as follows:

(a) Mahogany Rich (in the Mahogany Zone) - thickness of 50 to 65 feet with an average richness of about 31 GPT.

(b) R-5 - thickness of 150 to 210 feet with an average richness of about 29 GPT.

(c) R-4 - thickness of 100 to 160 feet with an average richness of about 32 GPT.

The above zonations conform to that established by the USGS (Oil and Gas Investigations Chart OC 65, Cashion and Donnell, 1972).

As the average grade of the open pit shale is lower than that of the shale from the selected underground mined zones, the latter will be blended in to raise the richness of the retort feed. The underground mining

production is expected to amount to approximately 20 percent of the combined open pit and underground output.

Underground operations will commence in the upper-most interval selected for underground mining, the Mahogany Rich Zone, and will proceed downward, mining out each zone in succession. Simultaneous operation in two or more intervals is not planned.

Entry to the underground mine in each zone will be by two parallel east-west adits starting at a suitable point and elevation in the open pit. They will be located in such a manner that the underground mining area is divided into two roughly-equal sub-areas, north and south of the adits. One sub-area will be mined on the advance of the adits and the other on the retreat.

The sub-areas will be further divided into mining panels, extending from the adits to the lease boundary in the north and to the main fault zone in the south. Multi-level mining will be employed in the panels, two levels in the Mahogany Rich and R-5 Zones, three or possibly four in Zone R-4. A typical panel is shown in Figure 3. The panel dimensions will be so chosen that the entire underground production can be supplied by one panel. On the other hand, the panels will be sufficiently small that they will be mined out quickly and then abandoned, thus eliminating potential hazards and expenses of keeping open old workings for longer periods of time.

Mining all zones will be by room-and-pillar method. Room width and pillar dimensions will vary in the different zones resulting in estimated mining recoveries of 60 percent in the Mahogany Rich Zone, 55 percent in Zone R-5, and 50 percent in Zone R-4. These recovery estimates may be conservative.

Data from test mines in other locations indicate that good possibilities exist for higher recoveries in actual operations.

Continuous barrier pillars will be left between adjacent panels. Experience obtained in actual operation will determine if these barriers can be totally, or partially, recovered at a later date.

Multi-drill jumbos will be used for drilling of the headings and multi-drill down-hole rigs for bench drilling. Explosives used will be ANFO prills, except where slurries are needed for higher loading density (e.g., in toe loading) or wet holes. Blasting will be electric; millisecond delay caps will be used as required. ANFO loading will be done by a loading truck equipped to pump slurries as well as load prills pneumatically. Presplitting will be used to limit overbreak and, in particular, to control pillar spalling.

In view of the relatively small tonnage of broken shale produced per round, highly mobile loading equipment is necessary to minimize unproductive loader traveling and idle time. Rubber-tired diesel powered front-end loaders are best suited for this application. Electric wheel mine trucks will be used to move the shale from the working face to the primary crushing stations.

Roof bolts will be used for roof support in all working areas, as well as in haulage-ways and adits. To ensure anchorage in competent rock, the roof bolts are assumed 10-foot long and spaced on 8-foot centers. Different bolt lengths and spacing, as well as steel cable, netting or straps, may be used if proven advantageous under actual operating conditions.

Based upon presently available hydrological information, it is expected that the dewatering system described in a later section will allow underground mining operations to be conducted relatively free of subsurface water. A system of sumps and pumps will be included in the mining plan for the removal of any water that does enter the underground workings.

Ventilation will be a forced draft system with exhaust fans at the adit portals and fresh air intake through vertical intake shafts surfacing outside the pit limits. Although in this system the air will flow against the natural draft, it is preferred over the natural draft system which would require intake through the adits with the possibility of introducing dust, powder fumes, etc., originating from the open pit operations.

Fresh air entering through the intake shaft--there will be one intake for each mining panel--will be swept along the working faces before being exhausted through the adits. The underground air flow will be directed and controlled by brattices and stoppings, and airlocks will be installed where needed to prevent short circuiting. Auxiliary portable fans will be installed as required, for example in dead-end workings.

6.1.3 SECONDARY CRUSHING PLANT

The crushed oil shale feed for the retorts will vary in size, depending on retort selection. To avoid possible handling and retorting difficulty and loss of oil shale, the retort feed should contain a minimum of fines. Although results from various testing programs indicate

this criterion can be met, more investigation is needed to determine the optimum type equipment for use.

Prior to entering the secondary crushing plant, the oil shale will be blended to provide uniform retort feed. A stockpile and blending area will be located at the terminus of the main conveyor from the primary crushers in the pit. Stockpiling will be accomplished by a swing boom stacker. Stockpiled ore will be reclaimed by a wheel reclaimer onto conveyors for delivery to the secondary crushing plant. The secondary crushing plant product will discharge to retort feed stockpiles.

6.1.4 SOLIDS DISPOSAL

During the premised 50,000 BPCD, 30-year mining operation, disposal will be required for about 400 million bank cubic yards of overburden and waste. In addition, about 800 million tons of spent oil shale from the retorting operation must be disposed of. The disposal areas selected are shown on Figure 1 and are off the tract to allow maximum development of the resource. Oil shale measures under the disposal areas are either so thin and lean, or so deeply buried, that development by open pit would be impractical.

Spent shale characteristics depend somewhat on the retort process; i.e., whether it is burned or unburned spent shale. Spent shale will average about 80 to 85 percent by weight of the raw shale, but will occupy about the same volume as the crushed shale feed. However, the crushed oil shale feed to the retorts occupies about 50-60 percent more volume

than oil shale in place due to the "swell" factor associated with mining and crushing. Therefore, it would not be feasible to return all of the spent shale to the mine even when compacted.

Area A and B will be used for initial overburden and waste disposal (see Figure 1). About 400 acres in Area A will be needed for disposal. Area B will be used for disposal of the bulk of the overburden and mine waste material. This disposal area will encompass something in excess of 1,000 acres. The area's proximity to the mine site and accessibility were the determining factors in its selection.

After overburden and waste materials have been conveyed out of the mine, stackers and/or dump trucks will be used for placement in the disposal areas (Areas A and B). The disposal system is designed to take advantage of the topography and to limit the height of the fill to 200-foot vertical increments. The exposed sloping faces will be rounded off and terraced, as discussed later in Section 6.1.6 on reclamation.

The surface areas selected for spent shale disposal are west of Tract C-a in Corral, Water and Box Elder Gulches (Areas C, D and E on Figure 1). These areas are located adjacent to the plant site (retorting and upgrading). Some 2,500 acres will be used for disposal; 1,200 acres in Corral and Water Gulches plus 1,300 acres in Box Elder Gulch. The final surface elevation of the spent shale might not exceed 7,500 feet, which will keep the top of the pile below the base elevation of the plant. At its ultimate height, the spent shale will be separated into three fingers by natural ridge lines extending more than 200 feet above the pile.

At its final position in the disposal area, the spent shale should be a well-compacted, highly impermeable embankment. The addition of about 20 percent water will assist in maximum compaction of the material. This condition will result in the following:

(a) Structural integrity.

(b) Reduced erodibility.

(c) Reduced permeability and leachability of salts.

(d) Reduced overall disposal volume requirements.

Compaction will be accomplished by a dual effort involving machinery and a sprinkler system.

In order to attain the desired compaction, the spent shale will be distributed over wide areas in shallow lifts. When dumping, the trucks will deposit the material in a windrow configuration. Next, dozers will spread the windrow in horizontal lifts of about one-foot depth, which will be compacted by self-propelled tamping foot rollers.

A water sprinkler system will be used for further compaction of the spent shale pile. Water will come from the mine dewatering system (discussed later). Initially, sprinklers will be installed and operated over the entire area for spent shale disposal. As increments of the area are filled with spent shale, the sprinklers and laterals will be relocated so as not to interfere with disposal operations.

Exposure of the spent shale pile to high intensity precipitation, flash floods, and wind erosion will be minimized by the construction of a surface water diversion system which will route surface runoff around the disposal areas. Advancing sets of ditches will be constructed around

the periphery of the spent shale disposal working areas. Water will be channeled from these ditches into natural drainage courses and thence into a downstream storage reservoir (discussed later). As a protective measure to insure downstream water quality, a collection dam downstream of the toe of the disposal pile will serve to reduce sediment load and provide a means for limiting or eliminating water with a high salt concentration from entering the natural stream system. Upon completion of the fill to elevation 7,500 feet, a permanent ditch will be constructed along the periphery of the spent shale disposal area.

6.1.5 DEWATERING

Limited information available on ground water conditions in the Piceance Creek Basin indicates that dewatering problems may be encountered in deep open pit and underground mining in the area. Data available for analysis, particularly of ground water aquifer characteristics, are not sufficient for precise quantitative evaluation of the problem. In general, the regional geohydrology indicates water flows in the Piceance Creek Basin are that of a normally circulating system with downflow on basin margins and upflow along the northern flank of the basin. Data also suggest that a portion of the ground waters may be too saline to be released into the natural surface drainage system without treatment.

In order to accommodate development of the mine, dewatering will have to be carried out in two phases. Phase I will require pumping from

deep wells located around the open pit perimeter during the first 5 to 10 years of the mining operation. During this time period the mine will be excavated to its maximum depth, and mining activity would make it impractical to dewater from benches as the mine is deepened.

After the open pit reaches maximum depth, adequate space will be available on the pit floor for installation of the permanent Phase II dewatering facilities. Gradual expansion of the Phase II well system will be tailored to the progress of the mining operation.

In view of the possible undesirable saline content of the ground waters, the discharge from the dewatering system may be disposed of in one or more of the following ways:

(a) Plant use.

(b) Evaporation from a sprinkler system.

(c) Evaporation in a downstream reservoir and/or

(d) Reinjection into the formation

Water for plant use will be pumped to a plant storage reservoir located on top of a hill near the processing plant. The storage reservoir will normally hold about 2 1/2 days water supply. It will be constructed by excavating an area adjacent to the plant and lining with asphaltic concrete over a layer of gravel.

Water exceeding the plant requirements will be evaporated during the warm season (about 6 months of the year) from a sprinkler system installed in the spent shale disposal area. During the months when the evaporation system cannot be used, water will be bypassed to a downstream

reservoir, where it will be stored until it can be delivered to the evaporating areas or to the plant.

The sprinkler system will be controlled so that the rate of application of water will be such that it will evaporate completely. However, if there should be any surface runoff, it will be intercepted in the downstream reservoir. Should any water percolate into the ground water, it will be within the drawdown zone of the mine dewatering system. Further protection against contamination will be provided when the area becomes blanketed by compacted spent shale and by impervious dikes constructed at the downstream toe of the disposal area.

The downstream storage reservoir might be constructed 3 miles from the northeastern corner of Tract C-a on Corral Gulch. The reservoir area will cover portions of Section 30 and 31 of T1S, R98W, and 25 and 36 of T1S, R99W. The reservoir dam will be a rockfill type with a clay core. The maximum water storage elevation of the reservoir will be 6,510 feet. The reservoir will cover about 700 acres.

It is believed that any percolation from the reservoir into the ground water will be minimal. Here again, any such leakage will be within the influence of the mine dewatering system and will be recirculated. Any excess leakage into the ground water could be controlled by pumping.

6.1.6 RECLAMATION

The effective safeguarding of the environment is an important part in the overall planning and development of an oil shale operation. Federal

and state regulatory agencies and industry have conducted individual, as well as joint, studies to develop sufficient knowledge so that the effect of full scale oil shale operations will have minimum impact on the environment. One of the more critical environmental items, for the mining-retorting operation, is the reclamation of disturbed areas. For the proposed project, the disturbed areas fall into two broad categories: (a) areas resulting from initial construction of plant facilities, mine development, overburden and waste disposal, utility corridors, roads, etc., and (b) areas of spent shale disposal.

The wide-spread emphasis currently being given to open pit operations and their effect upon the land warrants particular attention to the reclaiming and revegetation of the land that will be disturbed by this project.

The major land reclamation will be the rehabilitation and revegetation of the exposed surfaces of the waste dumps. Two types of waste dumps will result from the planned mining-retorting operations of this tract. The first type, consisting of overburden, barren material, and lean oil shale--all competent, strong material--will be fairly easy to shape and contour to blend with the existing topography. This type of waste may be easier to revegetate with proper seeding, fertilizing and watering. The second type of waste will consist of processed spent shale. This material may be more difficult to stabilize and to establish vegetative cover on. Available information does show that spent shale

can be compacted into stable spoil piles and that, with proper preparation, it can support vegetation.

Revegetation will be based on assisting the natural growth conditions which, at present, may be described as producing a submarginal grazing condition. The abandoned work areas, if left untreated, would be subject to excessive water erosion with further soil loss by wind action. Therefore, rehabilitation and revegetation procedures to provide contoured slopes with effective vegetative cover would be started upon the abandonment of each operational area and thus would be a continuing activity throughout the life of the project. Mechanical and biological factors necessary to insure the success of revegetative procedures will be determined during the baseline phase of the project (cf. 4.3, 4.3.1, 4.3.2), but may include the necessity of segregating salvageable topsoil during initial stripping operations, stockpiling it, and using it for ground cover in the clean-up phase.

The open-pit portion of the combination mining plan may be later expanded to cover the remaining area of the tract, where underground mining has not been attempted. In such case, overburden removed from open-pit mine expansion will be backfilled in the pit, if and when feasible. If the open-pit mine is not subsequently expanded, however, the pit at this stage could possibly be backfilled with spent shale produced from retorted oil shale mined from underground workings. Disturbed areas would be contoured to blend in with the natural landscape.

6.2 UNDERGROUND MINING PLAN

In the alternate mining plan presented here, the oil shale ore would be extracted entirely by underground room-and-pillar mining methods employing existing proven concepts and equipment designs. The size of pillars would be changed somewhat with depth of mining, effects of possible ground movements and/or ground subsidence. Figure 4 is a plan of underground mining for the tract, showing initial entry at the southwest portion of the lease, for a 100,000 BPCD operation.

In general, the mining plan would be to mine one side of the mine on the advance to the tract limits, and to mine the other side of the mine on the retreat. Also, at least three major mining levels of ore enrichment will be identified and eventually mined, leaving sufficient ground thickness between each level to support mining operations and minimize surface subsidence.

The percentage extraction of oil shale ore within the boundaries of Tract C-a (after allowing for the barrier pillars, main access entries, the secondary entries, etc.) will average about 60 percent at shallow depths and about 50 percent at deeper depths, since larger pillars must be left in place for ground support.

The oil shale will be drilled and blasted by using jumbo drill rigs and ammonium nitrate-fuel oil mixture. LHD (load-haul-dump) units will carry the broken ore to the underground portable crusher stations where it will be crushed to a maximum size of 8 inches for conveyance to

the surface. Crushed shale will be transported by belt conveyors from underground primary crusher locations to the retort plant on the surface, where it will be further crushed to the size desired.

The roof will be supported by rock bolts. Size and spacing of these supports will be determined by on-site tests, as will be the size of barrier pillars between panels and main headings.

Considerable oil shale mining research will be conducted prior to full scale mining to select a proper mining method, devise practices, develop new equipment designs and outline procedures for safe mining of oil shale on Colorado Tract C-a with a minimum of environmental impact. The mine designs and methods will be continually revised for better economics, production costs and handling of the operations.

6.2.1 MINE DEVELOPMENT

It is planned to gain access to the ore body by about 10- to 16-degree slope inclined adits. A set of two inclines will be driven to intersect the ore horizons. One of the inclines will be used for installing several sets of conveyor belts to transport ore to the surface, and also to convey spent shale from the surface to mined-out underground workings at a later date, if this procedure proves feasible from both operational and environmental standpoints. The other incline will be used as an access portal, and it will be collared and bottomed at the same elevations as the conveyor incline (see Figure 5). This portal will be equipped to accommodate two-way traffic entering and leaving the mine.

With completion of excavation of the incline portals, mine development will be started at the bottom of the portals by drifts and crosscuts in the ore horizon to be mined. As the main drifts are completed in the area, electric power cables will be installed from the surface substation down the incline conveyor portal to an underground substation. Also, two or more exhaust raises will be bored to the surface. A short section of gathering conveyor will be installed, together with one portable crusher station, to facilitate mine development operations. Surface activity during the period will include installation of mine dewatering pumps.

With completion of excavation of the initial development area at the bottom of the incline portals, mining crews, using standard production equipment, will begin development of production panels. Ore stockpiling facilities on the surface will be made ready to receive development ore. During the developmental stage 10-30,000 tons per day of ore will be extracted and sent to the surface stockpiles until they are full. After the development activities are completed sufficiently to open up enough panel entries and rooms, full scale production of ore will be started at 30,000 tons per panel per working day, increasing to a total of up to 250,000 tons per working day from all panel workings, depending on the grade of ore. It will take about three years from the start of underground development of panel entries and crosscuts to attain this full production rate.

6.2.2 BASIC MINING PLAN

The oil shale ore will be extracted by underground room-and-pillar mining methods employing proven concepts and equipment designs. Major zones of enrichment will be identified with further exploratory core drilling and quantitative analysis. Several intervals about 60-100 feet in thickness will be mined, and sufficient thickness between each level will be maintained to support mining operations and minimize surface subsidence.

Each standard mining block will consist of eight room openings 50 feet wide by 60-100 feet high and seven rows of pillars 60 feet by 60 feet square in section between 100-foot wide barrier pillars. Each room opening will be about 1,230 feet long in the direction of mining advance; room openings, on 110-foot centers (see Figure 6). Oil shale rock extraction in a block (within barrier pillars) will average about 70 percent, and overall extraction within the boundaries of Tract C-a (after allowing for the barrier pillars containing the main access entries, the secondary access entries, the incline portals, etc.) will average about 60 percent at shallow depths and about 50 percent at deeper depths, since larger size pillars must be left in the ground for roof support.

Each mining block will be serviced by an underground portable crusher station into which ore broken at the face by drilling and blasting will be discharged by large capacity rubber-tired LHD units. The portable crushers will be of the impactor-type, built to take mine-run feed of

-30 inch and produce a -8 inch product. The crushed ore will move by belt conveyors to the surface for processing.

In the mining sequence a diesel powered, hydraulically-operated mechanical heading scaler first moves in to remove the broken or loose rock which may have remained hanging to the roof of the heading or to its sides. Upon completion of the scaling job, this unit moves under its own power to the next heading. Next a drill rig moves into a mucked-out heading and bolts the roof over the previously blasted round with the machines atop the drill rig. The drill rig will then be finally positioned, and the round will be drilled according to a precise "V"-cut pattern using multiple drilling machines. The drilled round will then be charged with ANFO from the same drill rig, after which the unit will be moved to a safe distance for blasting.

Production equipment and manning for one mining block will include at least two combination roof bolt-drill-blasting rigs. Each rig will have a crew of about eight driller-blasters each shift to operate the two roof bolters, drills and ANFO blasting powder loading platforms on each rig. The LHD units will move the broken ore in the headings to the portable crusher station in the conveyor drift adjacent to the block (see Figure 6). Each mining block will produce about 30,000 tons of ore in three shifts. All diesel-powered units underground will be equipped with exhaust conditioners.

6.2.3 ORE HANDLING

Ore stockpiling facilities will be constructed on the surface to receive development and production ore. Several covered reclaiming galleries will be erected at the site of the coarse ore and fine ore stockpiles. A structure sized to support coarse ore stackout conveyors and trippers will be erected in the ore stockpile area to accommodate a pile of ore about 175 feet high by 400 feet wide and 1,360 feet long at the base.

Some of the reclaiming galleries under the coarse ore stockpile will be equipped initially to permit transfer of development ore to the secondary-tertiary crushers and to the fine ore stockpile. This partial equipping will require many stockpile reclaiming feeders, stockpile gathering conveyors (one in each gallery), and crusher feed conveyors to transfer the ore from the gathering conveyors to the secondary-tertiary crushers.

Secondary-tertiary crushing units will be housed in a 75-foot by 600-foot building. A similar plan will be used for handling fine ore stockpiles.

6.2.4 MINE VENTILATION

The ventilation of underground mine workings will be accomplished by an exhaust ventilation system. Exhaust ventilation raises will be bored on Tract C-a, at least two of which will be bored to intercept each mining level. There will also be several intake ventilation raises bored

into all levels from the surface when mine workings expand to full production rates. However, during initial development and production operations, mine access incline portals will be used as intake airways. The exhaust ventilation raises will be drilled near the bottom of the inclined conveyor and access adits, where these meet the mining level (see Figure 5). These exhaust ventilation raises will provide upcast ventilation for the mine throughout its productive life. Air volumes up the raises will total that needed for efficient ventilation of all underground mine workings. The quantity and speed of air will, of course, be based on total number of underground workmen and horsepower of mine diesel equipment and the particulate content of mine atmosphere. Up to five million cubic feet of fresh air per minute might be required to ventilate a mine producing 250,000 tons of ore per working day. To assist in moving air through the mine at reasonable velocities, several small auxiliary fans will be installed in the panels, near the working faces and other difficult ventilating areas of the mine.

6.2.5 MINE DEWATERING

It is stated in the final environmental impact study of the Department of the Interior that, ". . . at this time, the amount or quality of water can only be estimated, because neither complete hydrologic data nor detailed mining plans are available." This implies additional field data must be gathered on the underground water hydrology before mine development plans are finalized. Also, the final environmental impact study on prototype oil shale development states that there

would be a maximum of 30 cubic feet per second inflows from underground workings on Tract C-a, and up to a maximum of 70 percent of that would be of poor quality (up to 2,200 ppm dissolved solids), causing treatment and/or disposal problems. However, recent limited testing in the area indicates that the probable inflow will be less than 50 percent of that predicted in the final environmental impact study, and that it may be more usable than previously believed.

Gulf and Standard plan to study this problem very intensively, and choose the most economical and environmentally safe method of solving it. Alternatives to be explored are:

(a) Surround the mining area with a series of tube wells of sufficient capacity and at proper spacing to lower the water table surrounding the mine.

(b) Construct a network of underground, large diameter, "French-drain" type galleries for collection of inflow waters and delivery to control underground forebay and pumping station facilities.

(c) Grout the formation area surrounding the mine or seal off water by means of deep bentonitic curtains.

If alternatives (a) and (b) above prove to be the only ways to solve this problem, all, or most, of the poor quality water can probably be used for spent shale disposal; surplus poor quality water can be chemically treated in a reservoir and used, disposed of by natural evaporation or injected back into the formation through a series of deep wells.

6.2.6 SPENT SHALE DISPOSAL

During the production period, most of the spent shale produced by the retorts will be transported to the disposal area by a series of conveyors. Disposal will originate at the downstream point of filling, at the junction of Corral and Water Gulches and in Box Elder Gulch and Dry Fork, where retaining dams will be built. From this point, spent shale disposal will progress upstream. Large-diameter pipes will be placed along the bottom of these gulches and through the toe of the dam to facilitate rapid drainoff of water which might accumulate behind the compacted spent shale following periods of heavy rains and flash flooding. A recirculating pumping system below the dam will also be installed. Spreading and compaction of the spent shale will be accomplished by dozers and graders to insure maximum utilization of the disposal area and reduce the effects of erosion on the exposed surfaces of the piles.

A portion of the spent shale (perhaps about 50 percent) produced by retorting operations during later periods of mine operation will be disposed of in underground mined-out workings, if this procedure is proven to be feasible. The scheme envisaged is as follows: A totally-enclosed dry spent shale storage and water mixing system will be installed. The enclosure will prevent dusting of the powdery material by prevailing winds. Feeders mounted at draw points beneath the storage will meter the spent shale to one or two belt conveyors for underground disposal, and to a one-belt conveyor for surface disposal. The spent shale from all three conveyors will pass through a mixing plant where about 10-20 percent by weight of water will be added.

All spent shale produced by the retorts during the first few years after commencement of mining operations will be disposed of on the surface until sufficient space has been mined-out to permit a regular disposal schedule underground.

OIL SHALE
RETORTING AND UPGRADING

7.0 OIL SHALE RETORTING AND SHALE OIL UPGRADING

The information in this section pertains to retorting of shale and upgrading of the shale oil to low sulfur synthetic crude. Crushed shale is delivered to the retorts from the mining and crushing operations. Spent shale is released to a disposal operation. The product from upgrading is a very low sulfur synthetic crude which can be further processed in a conventional refinery to gasoline, jet fuel and other salable products. Product yields, utilities, manpower requirements and atmospheric emissions have been estimated. The average shale grade processed will vary from about 25 to 32 GPT depending on the mining plan adopted. About 90,000 to 180,000 TPD of shale would be retorted, depending on the size of the initial plant.

7.1 RETORTING

Retorting is the process of heating oil shale to about 900 degrees F. which causes the solid organic material in oil shale (called kerogen) to be converted into raw shale oil, various hydrocarbon gases and residual carbon. The residual carbon remains on the spent shale and serves as the fuel for some retorting processes. Other processes may burn the hydrocarbon gases, or some of the product oil may be recycled and burned, in order to generate the heat required.

The TOSCO II retort process is ready for commercial use according to its developers, and present plans are based on use of this method for Tract C-a. Other retorting techniques such as the Paraho process may be incorporated

in the final development plan. Gulf and Standard are both included among the sixteen sponsors of the current Paraho 30-month, $7.5 million development program.

The following tables (in Section 7.3) pertain to the TOSCO II process which has been demonstrated in a 1,000 TPD semiworks plant. In the TOSCO process raw shale is first crushed to minus 1/2 inch particle size and is then heated by flue gas from the ceramic ball heater in lift pipes. The flue gases are discharged to the atmosphere after flowing through dust removal equipment. The preheated shale flows to the inlet of the retort where it is contacted by heated ceramic balls from the ball heater. The temperature in the retort is sufficient to convert the kerogen into shale oil vapor and fuel gas. Ceramic balls and shale move by gravity to the exit end of the retort, where spent shale and balls are separated, and vaporized shale oil and product gas are discharged. The balls are recycled to the ball heater by means of an elevator which lifts them to the heater entrance. The spent shale passes through a steam generator and then to the spent shale cooler, where it is cooled by water addition. Vapor from the retorts flow through dust removal equipment before it is cooled. Condensed shale oil is separated from vapor. The liquid flows first to tankage, and vapor flows directly to the product upgrading section. The retort plant will consist of multiple retort trains, each with a capacity of about 10,000 TPD of oil shale.

7.2 OIL UPGRADING FACILITIES

Raw oil produced from the retorts is of poor quality compared to most crude oils. Although sulfur level is relatively low (0.8 weight percent),

it has a very high nitrogen content (1.8 weight percent), a high pour point (70-80 degrees F.) and a 18-22 degrees API gravity. The high pour point creates a problem from the standpoint of transporting the raw crude to market centers. The high nitrogen content would make the raw crude an undesirable refinery charge stock, since nitrogen is a catalyst poison; also, air pollution regulations would limit the raw crude's value as a fuel oil due to the high concentration of nitrogen oxides which would be present in the combustion gases. For these reasons, it will be desirable to include partial refining or oil upgrading facilities at the retort site to process the raw oil into a clean marketable synthetic crude.

These facilities will include atmospheric distillation to separate the retort products into light hydrocarbon gases, naphtha, gas oil and heavy oil boiling above 900 degrees F. This heavy oil would be charged to a delayed coking unit where the oil would be thermally cracked, forming additional gases, naphtha, gas oil and coke. Naphtha and gas oils would be charged to separate hydrogenation units to remove nitrogen and sulfur. Due to the high nitrogen content, severe conditions would have to be employed in these units (low-space velocity and relatively high pressure).

Also included in the upgrading facilities would be a large hydrogen plant, a gas treating plant (to remove hydrogen sulfide and ammonia), a plant to recover hydrogen sulfide and ammonia from sour water and a plant to convert hydrogen sulfide to elemental sulfur. Butanes from the gas plant, hydrogenated naphtha, and hydrogenated gas oil would be combined to form pipeline synthetic crude. The pipeline crude would have a gravity of 40-45

degrees API, a nitrogen content of 0.05-0.20 weight percent, a sulfur content of 0.01-0.05 weight percent and a pour point of 30-60 degrees F. Byproducts would include ammonia and elemental sulfur; it is uncertain at this time if coke will be of satisfactory quality to find a market.

7.3 FUEL, POWER AND WATER REQUIREMENTS

The combined retorting and upgrading facilities have been designed to be fuel self-sufficient. After satisfying hydrogen plant requirements, the treated (Hydrogen Sulfide free) fuel gas produced in the processing will be used to fire process heaters. In addition, low sulfur (0.05 weight percent) hydrotreated gas oil will be used to supply process heat; a portion of this stream will be used as diesel fuel for mining, crushing and spent shale disposal activities.

Tables 7.3.1, 7.3.2 and 7.3.3,which follow, list the product yields, utilities requirements and expected atmospheric emissions from a 50,000 BPCD operation.

The water requirements shown on Table 7.3.2 are based on the assumption that process water would be derived from ground-water sources.

Based on limited knowledge of the aquifer characteristics, it is estimated that the mine dewatering rate will be nearly constant for the duration of the project. For a 50,000 BPCD operation, approximately 12,000 acre-feet of water may be obtained annually by dewatering the open pit and underground workings. This approximately balances the total water required for the oil shale operations.

Only after the hydrologic testing program proposed for the tract is completed, will it be possible to predict whether a water surplus or

deficit exists. As previously noted, if insufficient water is produced during dewatering, additional water source wells can be drilled on or near the tract. If the water deficit is severe, it may be necessary to import water from the White or Colorado Rivers via pipeline. Conversely, if dewatering produces a surplus of water, some means of disposal must be found. Reinjection, evaporation or transportation of the surplus water to a water-short oil shale operation are three possible approaches for disposal of surplus water that will be investigated further.

TABLE 7.3.1

PRODUCT YIELDS
50,000 Barrels/Calendar Day of Syncrude
27 Gallons/Ton Shale

Raw Shale Requirement	
Tons/Stream Day	101,000
Tons/Calendar Day [(a)]	90,900
Syncrude, Barrels/Stream Day [(b)]	55,560
Gas Oil Fuel, Barrels/Stream Day [(c)]	5,150
Fuel Gas, Millions of BTU's/Stream Hour	3,270
Sulfur, Tons/Stream Day [(b)]	228
Ammonia, Tons/Stream Day [(b)]	168
Coke, Tons/Stream Day [(b)]	602
Spent Shale	
Tons/Stream Day	89,800
Tons/Calendar Day	80,800

(a) A 0.9 operating factor basis. Tons pertains to short tons
(b) Salable products
(c) Fuel for mining, retorting, upgrading and utilities production

TABLE 7.3.2

UTILITIES REQUIREMENTS
50,000 Barrels/Calendar Day of Syncrude
27 Gallons/Ton Shale

Power, KW [(a)]	
Mining [(b)]	37,600
Retorting-Upgrading	51,350
Utilities Production	5,400
Total	94,350
Fuel, Millions of BTU's/Stream Hour	
Gas [(c)]	3,270
Gas Oil [(d)]	1,020
Total [(e)]	4,290
Water Requirements, Acre Feet Per Year	
Cooling Tower Evaporation	3,600
Cooling Tower Blowdown [(f)] [(g)]	3,600
Steam Losses	2,700
Steam Boiler Blowdown [(g)]	200
Addition to Spent Shale Disposal and Vegetation [(g)]	1,100
Total [(h)]	11,200

(a) Purchased
(b) Mining includes dewatering, drilling, blasting, loading, crushing, transport, stockpiling, blending, feeding retorts, and spent shale transport and disposal
(c) The total produced
(d) 5.46 Million BTU's/Barrel (Low Heat Value)
(e) Does not include 650 Barrels/Stream Day of diesel fuel
(f) The anticipated makeup water quality requires a large cooling tower blowdown rate
(g) Utilized to moisturize spent shale. About 20 weight percent water (based on spent shale) is added to spent shale for disposal
(h) About 300 acre feet per year additional would be required for crushing and mining

TABLE 7.3.3

ATMOSPHERIC EMISSIONS (a)
50,000 Barrels/Calendar Day of Syncrude
27 Gallons/Ton Shale

ITEM	ST/SD (b)
Sulfur Dioxide	5.0
Carbon Monoxide	7.2
Hydrocarbons	10.8
$(NO)_x$	15.7
Aldehydes	0.2
Particulates	3.3

(a) Emissions from fuel oil and fuel gas combustion, sulfur plant tail gas, the coker, tankage, diesel engine exhaust, and miscellaneous seal losses

(b) Short tons per stream day

OFF-SITE FACILITIES 8

8.0 OFF-SITE FACILITIES

Except for the mine workings, all of the major facilities associated with development of Tract C-a are tentatively located off the tract. This arrangement appears to fit the guidelines established in the federal oil shale impact statement, and is commensurate with preliminary site planning criteria.

The final location of each of these facilities is heavily dependent on: (a) the results of the extensive engineering and environmental studies described elsewhere in this preliminary development plan; (b) the determination and settlement of conflicting rights, if any, in site areas; and (c) the negotiation of suitable arrangements for use of the required surface.

However, this preliminary development plan includes off-site facility considerations as discussed in the following text, and as shown in Figure 1 and/or Figure 4 in the appendix.

8.1 ACCESS

It is anticipated that major access to mining and processing facilities will be from the east. However, alternate access roads from Highway 64, some three miles east of Rangely or from the west, from Highway 139 may also be built (see Figure 8). The general plan is to construct an improved all-weather road from the paved Piceance Creek (county) road some twelve miles east of Tract C-a into the industrial area, probably following the Ryan Gulch and/or Stake Springs drainage

in part. Hopefully, suitable arrangements can be made for building this road for heavy traffic loads and paving it concurrent with the start of major construction. Several thousand tons of by-products such as coke, ammonia, sulphur and diesel fuel will have to be trucked out each day from Tract C-a to the D&RGW rail head at Rifle some 65 miles away.

An alternative to rebuilding the Piceance Creek and Ryan Gulch roads for heavy traffic would be to extend the railroad from Rifle to the tract, either directly or through Rangely.

New roads that may be built will follow existing roads and trails wherever feasible. They will be constructed according to specifications of the Bureau of Land Management and the Colorado State Highway Department. Suitable drainage structures and erosion protection will be included in the design.

Uphill slopes where cuts are made will be revegetated or covered as necessary to prevent erosion and divert runoff. Environmental effects will be minimized during construction and maintenance by careful design and planning.

Provision will be made for road crossings for major game migration or livestock movement. Road construction will be carried out so as to not prevent the use of existing roads, trails, pipelines, and other rights-of-way. Alternate routes or detours will be provided in case it is impossible to avoid shutting off travel during construction periods.

8.2 DRILL SITES AND ENVIRONMENTAL MONITORING STATIONS

As explained elsewhere in this document, it will be necessary in the pre-mine development period to construct a number of drill hole sites and the stations for various environmental monitoring programs. The precise location of these sites has not been determined, but it is probable that several of them will be established off Tract C-a. It may be necessary to construct roads to these sites; however they will be located near existing roads wherever possible to minimize environmental impact. In any event, these off-tract development sites should not have a major effect on the environment.

8.3 POWER SUPPLY

The magnitude of the full operating power requirement for producing shale oil at the rate of 100,000 BPCD from Tract C-a will impose a new load in the region - much larger than has been contemplated by the utilities serving the area. Approximately 200 MW (megawatts), with a peak requirement possibly as high as 300 to 325 MW, will be required at full rate production of shale oil from this tract alone. Therefore, this power requirement must be provided for by new electric power generating facilities not yet contracted for, nor under order. The steam plant construction already underway by Utah Power and Light Company at Huntington Canyon, proposed Colorado-Ute plant near Craig, Colorado, and planned expansion of Jim Bridger Plant of Pacific Power and Light Co. near Rock Springs, Wyoming, will create new generating capacity in the order of

2500 MW by the early 1980's. However, very little of this appears to be available for the proposed oil shale development operations on Tract C-a.

The power plant construction underway or scheduled is to take care of the increasing load requirements of the respective utility systems, except for about 100 MW which could be put together for construction of facilities on Tract C-a; this could be brought to the project over the existing 138 KV transmission system in the area some 13 miles to the north of the tract. Some seasonal power and about 5 MW of hydroelectric power from the U.S. Bureau of Reclamation Crystal power plant will also become available by 1981.

The power needed for Tract C-a falls within the service area of the Moon Lake REA, headquartered at Rangely, Colorado, or White River Electric Association, headquartered at Meeker, Colorado, and it can be assumed that they might provide the electrical distribution for project development on Tract C-a. In order to assure dependability and flexibility, the new power for Tract C-a development must, ideally, be transmitted from the above or other outside sources by a new transmission line of 345 KV capacity tied into the western Colorado-eastern Utah transmission network.

Gulf and Standard intend to make early arrangements for the necessary power for the project, and anticipate that, after such arrangements are made, the firm or firms involved will be responsible for siting and installation of the necessary power transmission lines.

8.4 WATER SUPPLY

Our planned investigation and development of water resources for development of Tract C-a are covered in detail elsewhere in this document. This investigation may indicate that supplemental water will have to be developed either from surface water rights or from deep wells. In this case, it may become necessary to construct pipelines, canals and/or storage reservoirs off Tract C-a. These facilities will be constructed in accordance with accepted engineering and environmental criteria.

8.5 MINING FACILITIES

As presently planned, off-tract mining facilities will consist of offices, changehouse, shops, roads, parking, and material storage. The facilities would be located just west of Tract C-a, either near the northwestern or the southwestern corner. In addition, the all-underground mining plan would require portal sites for access inclines in Box Elder Gulch, also just off the tract.

8.6 PROCESSING FACILITIES

Retorting and upgrading facilities are tentatively planned to occupy an area either along the ridge between Corral and Box Elder Gulches or between Water Gulch and Dry Fork. The areas are approximately one and one-half miles west of Tract C-a,as shown on Figures 1 and 4.

8.7 SHALE TRANSPORTATION AND STOCKPILING

Our present plan is to place fine and coarse oil shale ore stockpiles also along the ridges near processing facilities on the western side of Tract C-a. Covered conveyor belts will run between the mine, oil shale ore stockpiles and processing area.

8.8 OVERBURDEN AND SPENT SHALE DISPOSAL

The overburden and waste oil shale rock will be disposed of either in Dry Fork to the west of Tract C-a or in Sections 21, 22, 23, 26, 27 and 28 of Township 1 South, Range 99 West, to the north of the tract.

In accordance with the alternate mining plans presented herein, the Companies would place spent shale, as necessary, in Corral, Water and Box Elder Gulches and in Dry Fork. The extent and depth of the area covered by spent shale will be dependent on the amount of this material which can be placed back in worked-out areas of the mine. At the present time, however, it appears that spent shale will occupy up to the 7,500-foot elevation contour line in all these areas.

8.9 PRODUCT PIPELINES

It is intended that the upgraded shale oil will be carried away from the project by pipeline. However, no plans have been made at present for the siting or sizing of product pipelines. Pipeline sites must await the determination of markets and regional interties. There are several

possible routes, one of which might handle an initial production of up to 50,000 BPCD in the existing 10-inch systems with terminals near Rangely, Colorado. Some oil might flow west towards Salt Lake City or north and east via Wyoming, depending on pipeline loading at the time.

Expanded production would require construction of new pipelines. One such possibility is a 16-inch or larger diameter line from the lease site northeast toward a junction with existing pipelines at Sterling, Colorado, from where the syncrude would flow to Midwest refining centers. This line would be about 360 miles long, and might also include production from other oil shale plants.

PROJECT SCHEDULES

9.0 PROJECT SCHEDULE

The following tentative work schedule of project development, by combination open pit-underground room-and-pillar, or by all underground room-and-pillar mining method, is proposed for Tract C-a for the guidance of the Mining Supervisor:

January 8, 1974 through April, 1974 (3-1/2 months)

Project planning, organizing and coordination.

May, 1974 through January, 1976 (21 months)

(a) Gather environmental baseline data of all components of physical, biological, human and socioeconomic environment in the area.

(b) Carry on mining, retorting and upgrading engineering and research.

(c) Conduct research in vegetating spent shale disposal areas and in many other problem areas.

(d) File with Mining Supervisor an exploration plan, and a fish and wildlife management plan.

(e) Drill additional holes on the tract to develop necessary data pertaining to structural geology, underground hydrology, quality of water to be encountered, quality of oil shale rock to be mined, etc.

(f) Commence preparation of detailed plans and designs

for mining, retorting, upgrading and other on- and off-tract facilities* early in 1975.

(g) Begin acquiring surface rights for on- and off-tract facilities as needed.

February, 1976 through January, 1977 (12 months)

(a) Continue preparing detailed plans and designs for mining, retorting, upgrading and other on- and off-site facilities*, based on environmental data gathered to date. Develop time schedules of all project job networks in detail.

(b) Continue environmental baseline studies in some fields as required.

(c) Continue mining, retorting and upgrading engineering and research as necessary.

(d) Continue research in revegetating spent shale disposal areas.

(e) Continue surface acquisition as necessary.

(f) Secure approval of project development plans, including spill-contingency plan, by the Mining Supervisor; make revisions and modifications of the same, if needed.

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* Including,but not limited to,access roads, site upgrading, dewatering systems, deep well installations, dam and reservoir construction, primary and secondary and tertiary crushing and conveying, surface drainage and water control plans, overburden and spent shale disposal site plans, other support facilities, etc.

(g) Release engineering specifications for equipment designs and release to manufacturers for competitive bidding.

(h) Initiate procurement of mining, construction and processing plant equipment.

<u>February, 1977 through January 1978 (12 months)</u>

(a) Acquire surface rights for on- and off-tract facilities as needed.

(b) Continue baseline data gathering for environmental criteria in some fields until the Mining Supervisor authorizes termination.

(c) Submit to the Mining Supervisor an erosion control and surface rehabilitation plan and an archaeological and historic investigations report.

(d) Continue procurement of mining, construction and processing plant equipment.

(e) Begin site preparation for various surface installations including overburden waste and spent shale disposal sites, water storage reservoirs and other facilities.

(f) Make arrangements for construction power from the utility or REA serving the area.

(g) Begin overburden waste removal in the case of open pit mining method.

(h) Begin boring incline conveyor portal and incline access portal (in the case of all underground room-and-pillar mining method) to mining zones and installation of conveyor belts.

(i) Carry out rehabilitation of disturbed land areas.

(j) Control surface and/or underground water discharge as necessary.

<u>February, 1978 through January, 1979 (12 months)</u>

(a) Continue site preparation for various surface installations, including spent shale disposal areas off the tract as needed.

(b) Complete boring incline conveyor portal and incline access portal (in the case of all underground room-and-pillar mining method) to mining zones and installation of conveyor belts; concrete lining in the incline access portal, etc.

(c) Continue overburden waste removal in the case of open pit mining method.

(d) Construct surface facilities, including crushing, blending and ore stockpile facilities.

(e) Continue procurement of mining, construction and process plant equipment and prepare final construction drawings for these facilities.

(f) Complete arrangements for construction power from the utility or REA serving the area.

(g) Carry out rehabilitation of disturbed land areas.

(h) Control surface and/or underground water discharge as necessary.

<u>February, 1979 through January, 1980 (12 months)</u>

(a) Complete boring of exhaust ventilation raises from the underground mining zones to the surface.

(b) Continue overburden waste removal in the case of open pit mining method.

(c) Start underground mine development headings, in the case this method is followed and attain open pit and/or underground mine production at 10 percent of full rate and stockpile the ore on the surface.

(d) Begin construction of retorting and upgrading facilities and complete 10 percent of total works.

(e) Continue construction of surface mine facilities.

(f) Continue procurement of mine and process plant equipment.

(g) Carry out rehabilitation of disturbed land areas.

(h) Control surface and/or underground water discharge as necessary.

February, 1980 through December, 1980 (11 months)

(a) Continue overburden waste removal in the case of open pit mining method.

(b) Continue open pit or underground mine development and production and produce oil shale at daily production of 30 percent of full rated capacity.

(c) Begin retorting and upgrading of oil shale at about 10-20 percent of full load capacity.

(d) Complete construction of retorting and upgrading facilities up to 50 percent of ultimate full capacity.

(e) Start spent shale disposal on the surface.

(f) Continue procurement of mine and process plant equipment.

(g) Carry out rehabilitation of disturbed land areas.

(h) Control surface and/or underground water discharge as necessary.

January, 1981 through December, 1981 (12 months)

(a) Continue overburden waste removal in the case of open pit mining method.

(b) Continue open pit and/or underground mine development and production at 50 percent of rated full capacity.

(c) Retort and upgrade 50 percent of rated full capacity.

(d) Continue construction of process plant facilities and complete all works.

(e) Continue spent shale disposal on the surface.

(f) Continue procurement of mine and process plant equipment.

(g) Carry out rehabilitation of disturbed land areas

(h) Control surface and/or underground water discharge as necessary.

<u>January, 1982 through Project End</u>

(a) Continue overburden waste removal in the case of open pit mining method.

(b) Produce oil shale by open pit and/or underground mining method at rated full capacity.

(c) Operate retorting and upgrading facilities at full rate.

(d) Continue spent shale disposal on the surface during initial years and in underground workings during later years, if proven feasible.

(e) Rehabilitate and reclaim disturbed lands resulting from mine and plant activities and overburden waste and spent shale disposal on the surface.

(f) Continue environmental monitoring program to evaluate adverse impacts if any.

(g) Revise and modify mining plans, as warranted by newly-found mining and processing data and environmental monitoring programs.

(h) Carry out rehabilitation of disturbed land areas.

(i) Control surface and/or underground water discharge as necessary.

Summaries of this schedule are shown in the following:

Chart 9.1 and Chart 9.2

CHART 9.1

COLORADO TRACT C-a
TENTATIVE SCHEDULE OF PROJECT DEVELOPMENT FOR MINING, RETORTING & UPGRADING

(FOR THE GUIDANCE OF MINING SUPERVISOR)

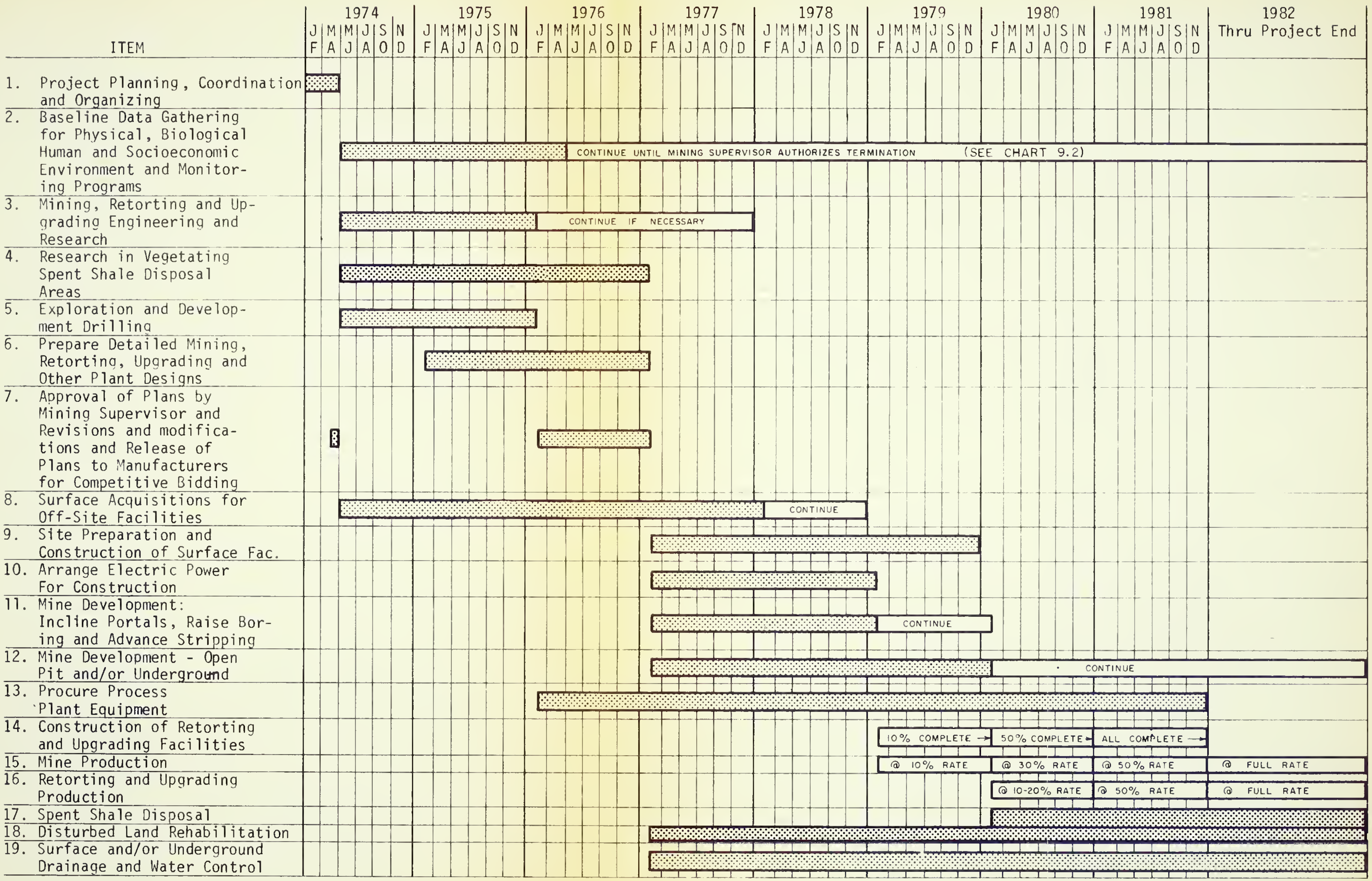
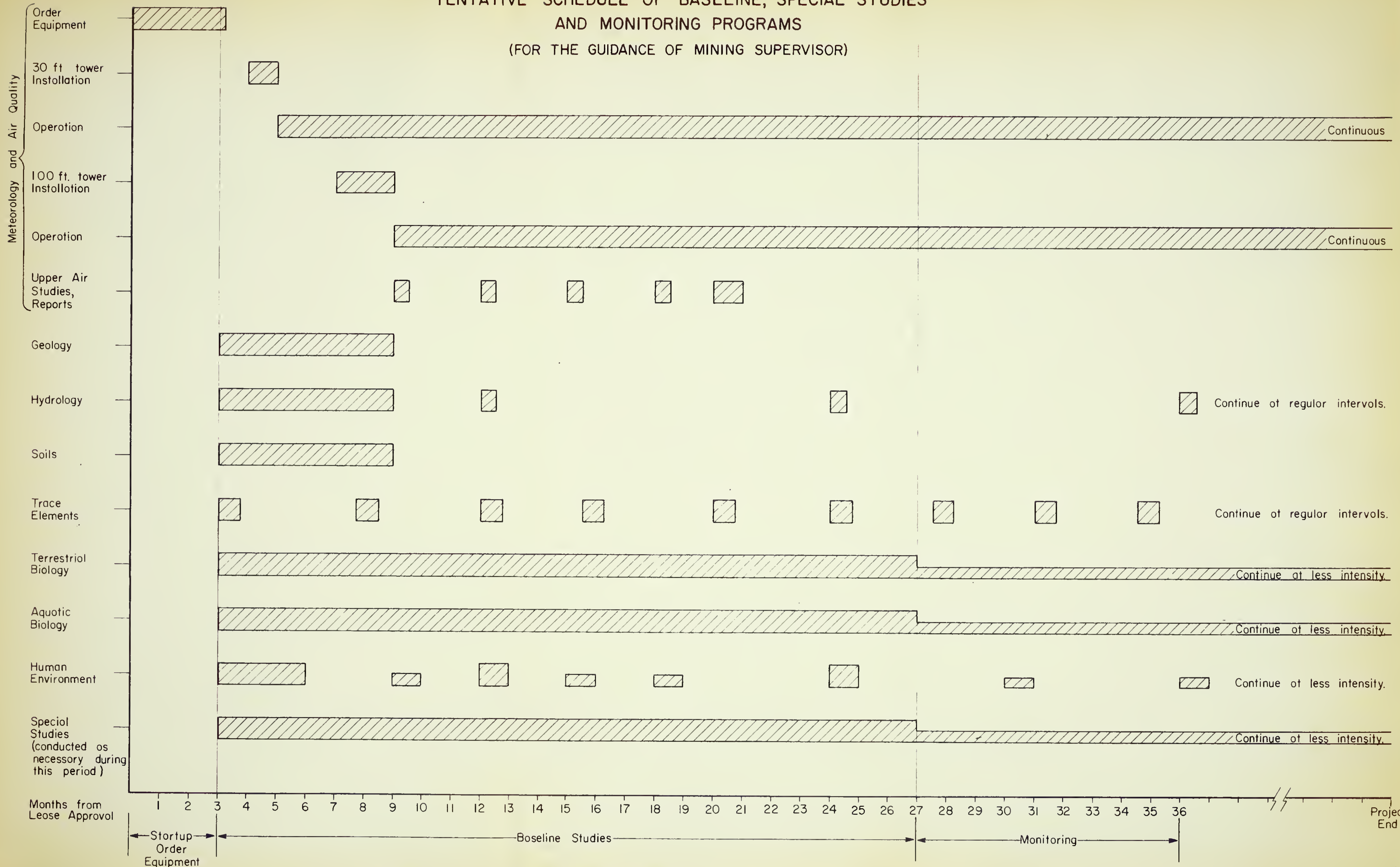


CHART 9·2

COLORADO TRACT C-a

TENTATIVE SCHEDULE OF BASELINE, SPECIAL STUDIES AND MONITORING PROGRAMS

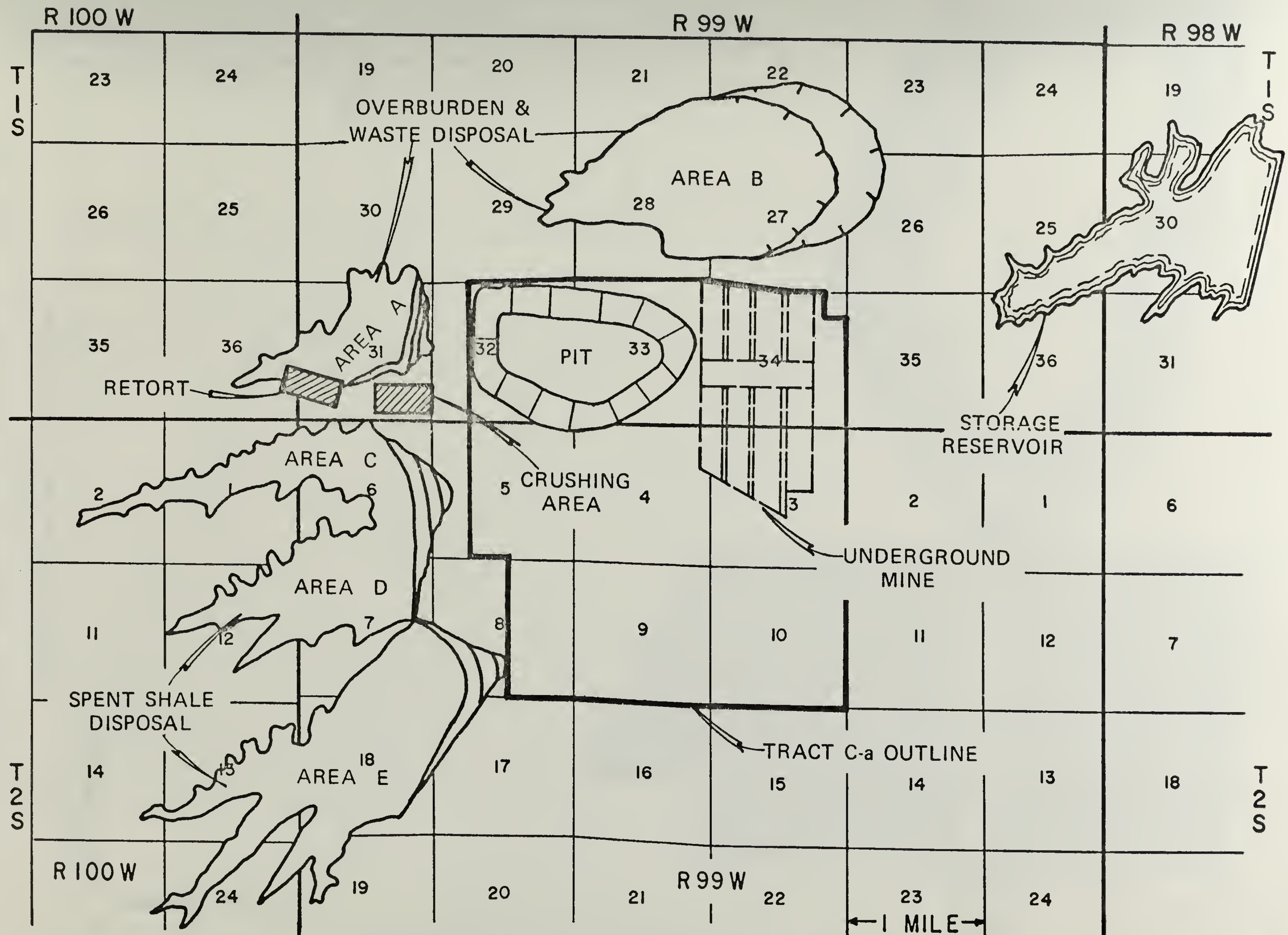
(FOR THE GUIDANCE OF MINING SUPERVISOR)



Note: Height of block represents intensity of the study.

APPENDIX

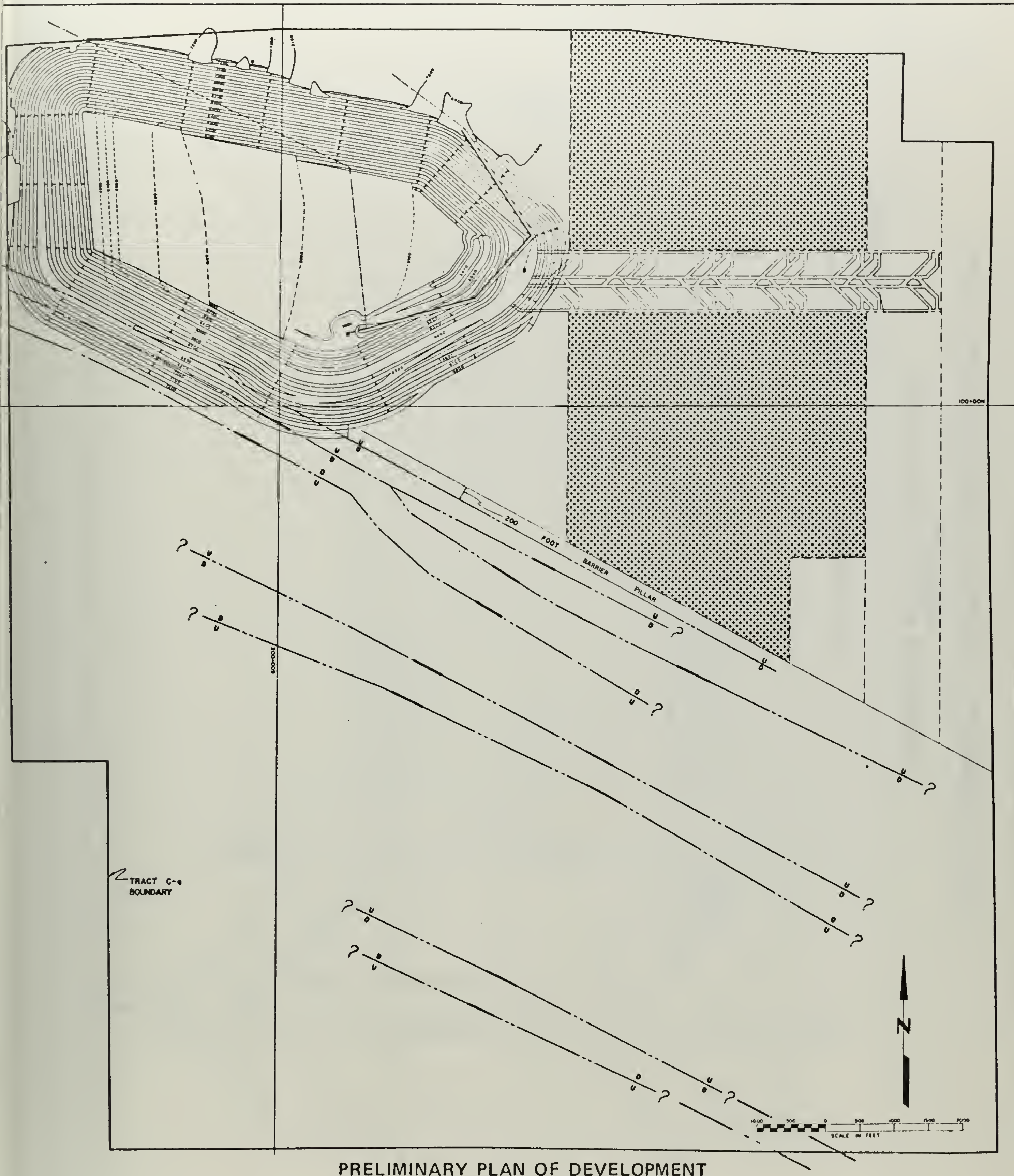
10.0 APPENDIX



PRELIMINARY PLAN OF DEVELOPMENT
TRACT C-a

PLAN OF OPEN PIT/UNDERGROUND COMBINATION MINING SCHEME
SHOWING MAJOR OFF-SITE FACILITIES

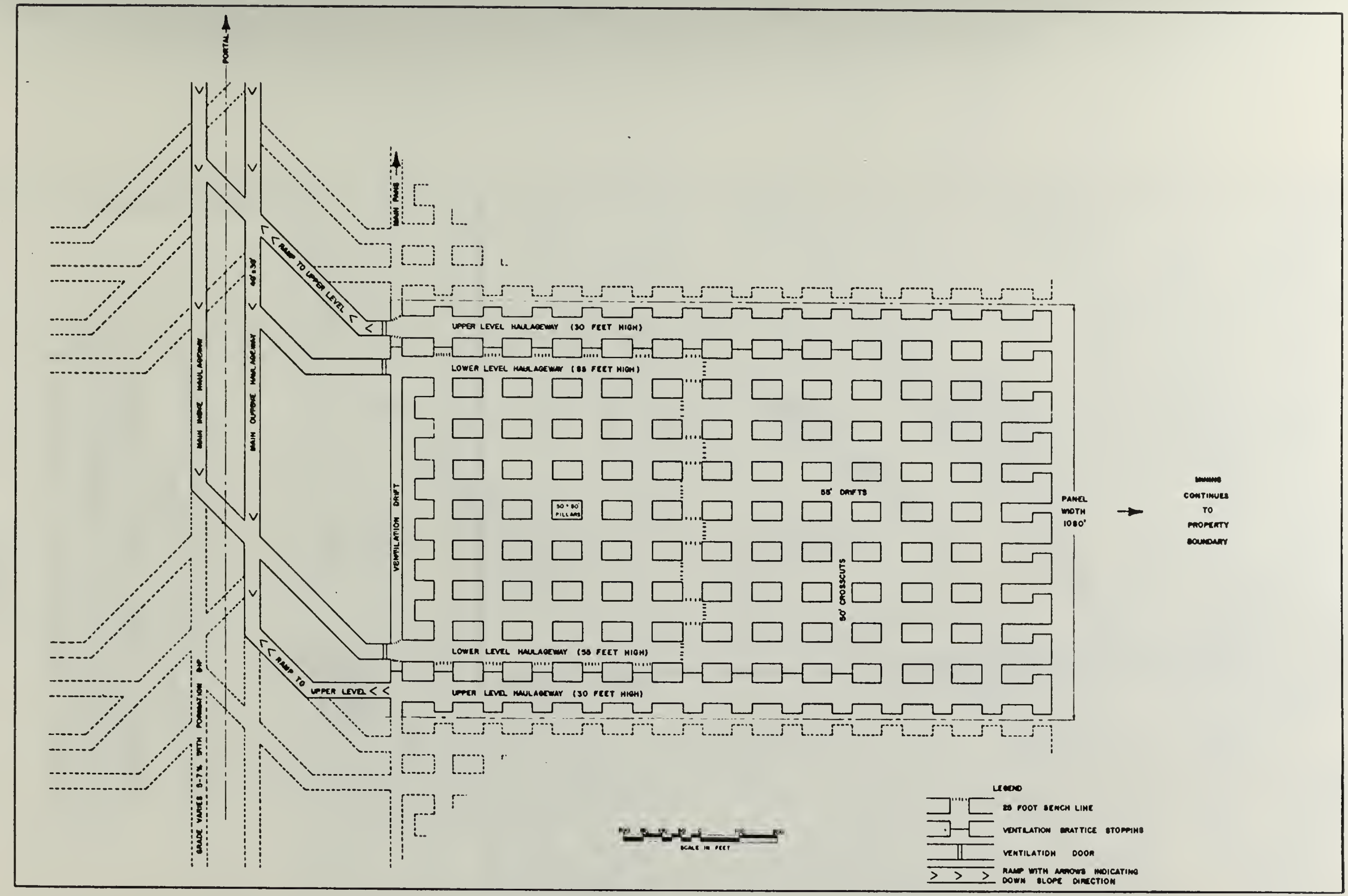
Fig. 1



PRELIMINARY PLAN OF DEVELOPMENT
TRACT C-a

PLAN OF OPEN PIT/UNDERGROUND COMBINATION MINING SCHEME
SHOWING THE MINE OUTLINE AFTER 30 YEARS

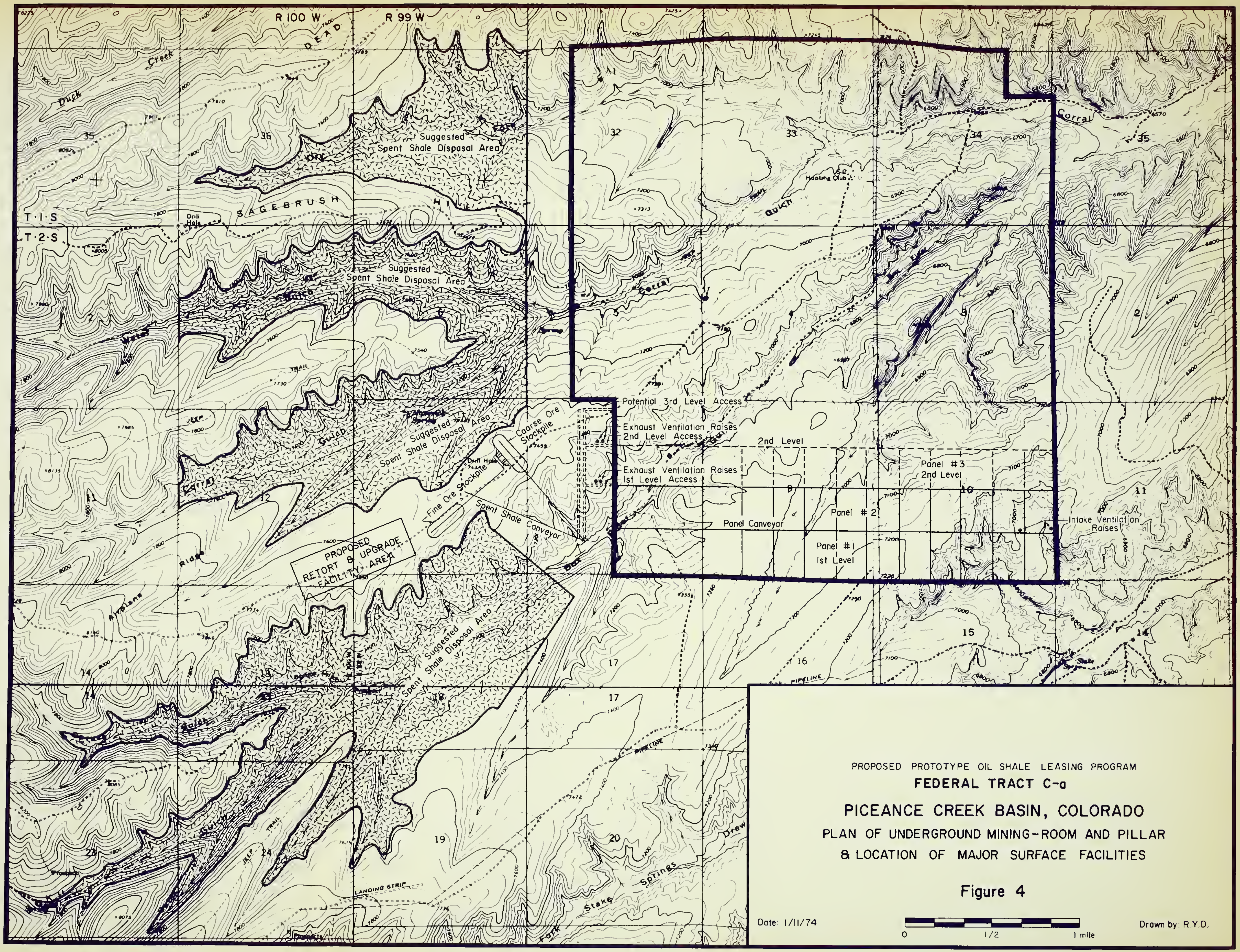
Fig. 2



PRELIMINARY PLAN OF DEVELOPMENT
TRACT C-a

PLAN OF UNDERGROUND PORTION OF COMBINATION MINING SCHEME

Fig. 3



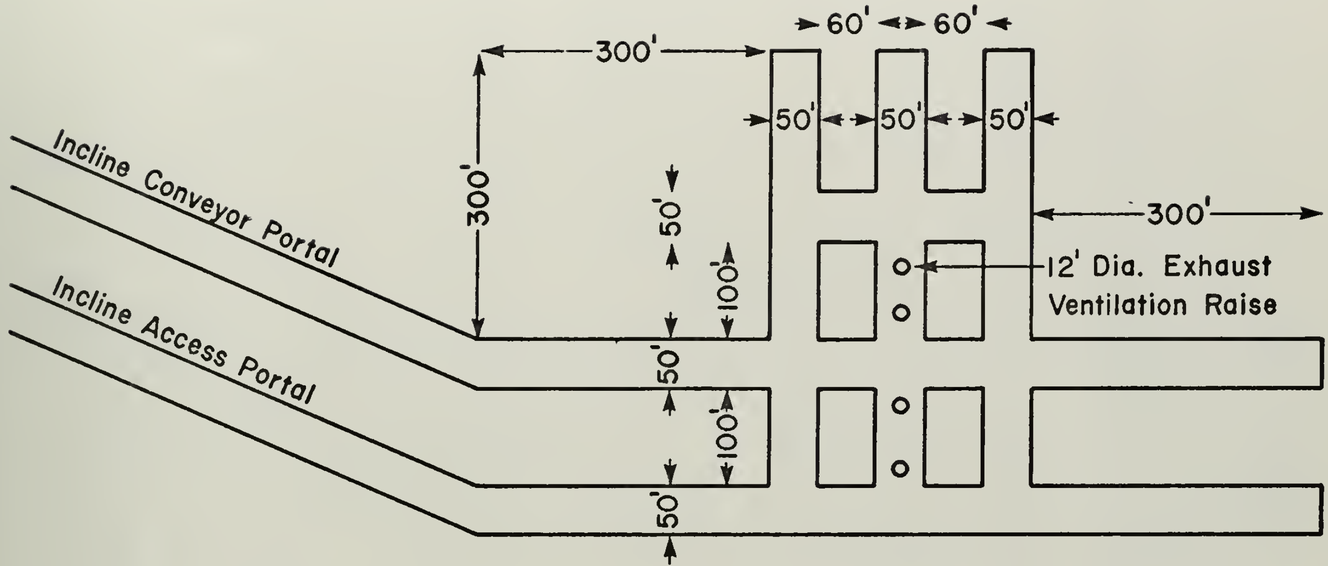
PROPOSED PROTOTYPE OIL SHALE LEASING PROGRAM

FEDERAL TRACT C-a

PICEANCE CREEK BASIN, COLORADO

PLAN OF UNDERGROUND MINING-ROOM AND PILLAR & LOCATION OF MAJOR SURFACE FACILITIES

Figure 4



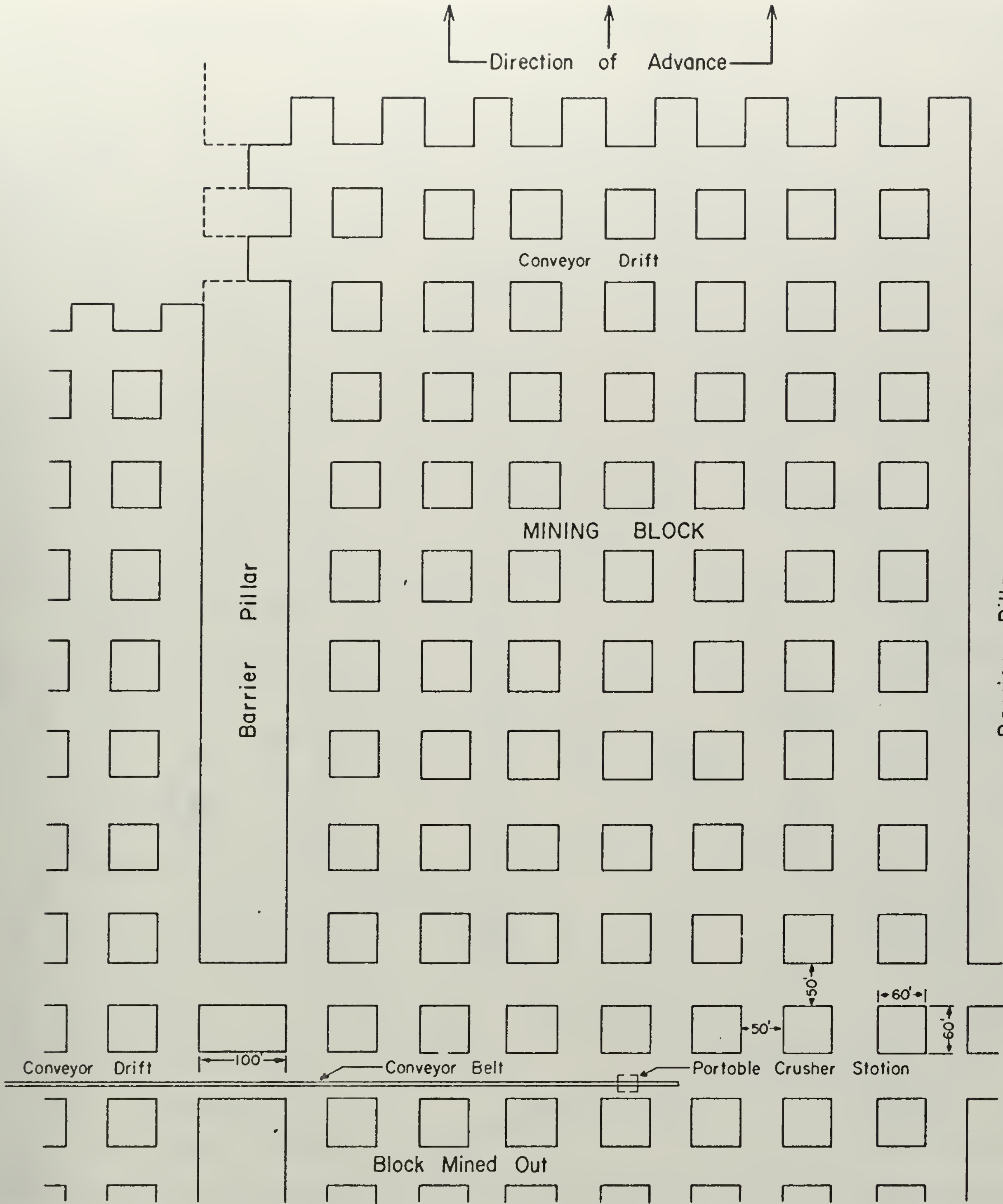
PROPOSED PROTOTYPE OIL SHALE LEASING PROGRAM

FEDERAL TRACT C-a

UNDERGROUND ROOM & PILLAR MINING METHOD—
PLAN OF DEVELOPMENT
INITIAL MINE OPENINGS

Figure 5

12-27-73 Scale: 1"=200' llw



PROPOSED PROTOTYPE OIL SHALE LEASING PROGRAM

FEDERAL TRACT C-a

PICEANCE CREEK BASIN, COLORADO

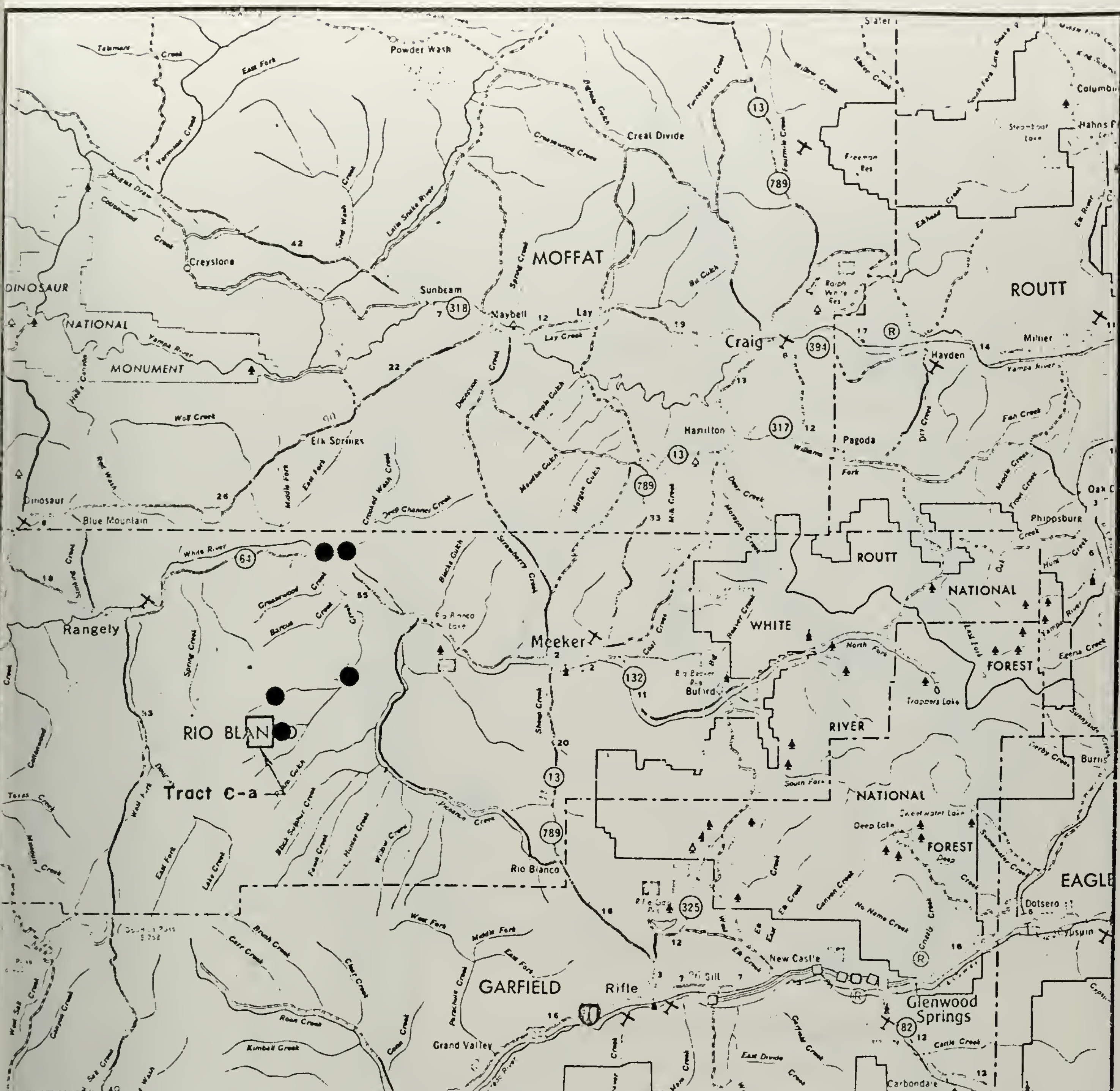
PLAN OF TYPICAL MINING BLOCK–
UNDERGROUND ROOM & PILLAR MINING

Figure 6

Scale: 1" = 200'

12-27-73

llw



PROTOTYPE OIL SHALE DEVELOPMENT

COLORADO TRACT C-a

WATER SAMPLING LOCATIONS

FIGURE 7

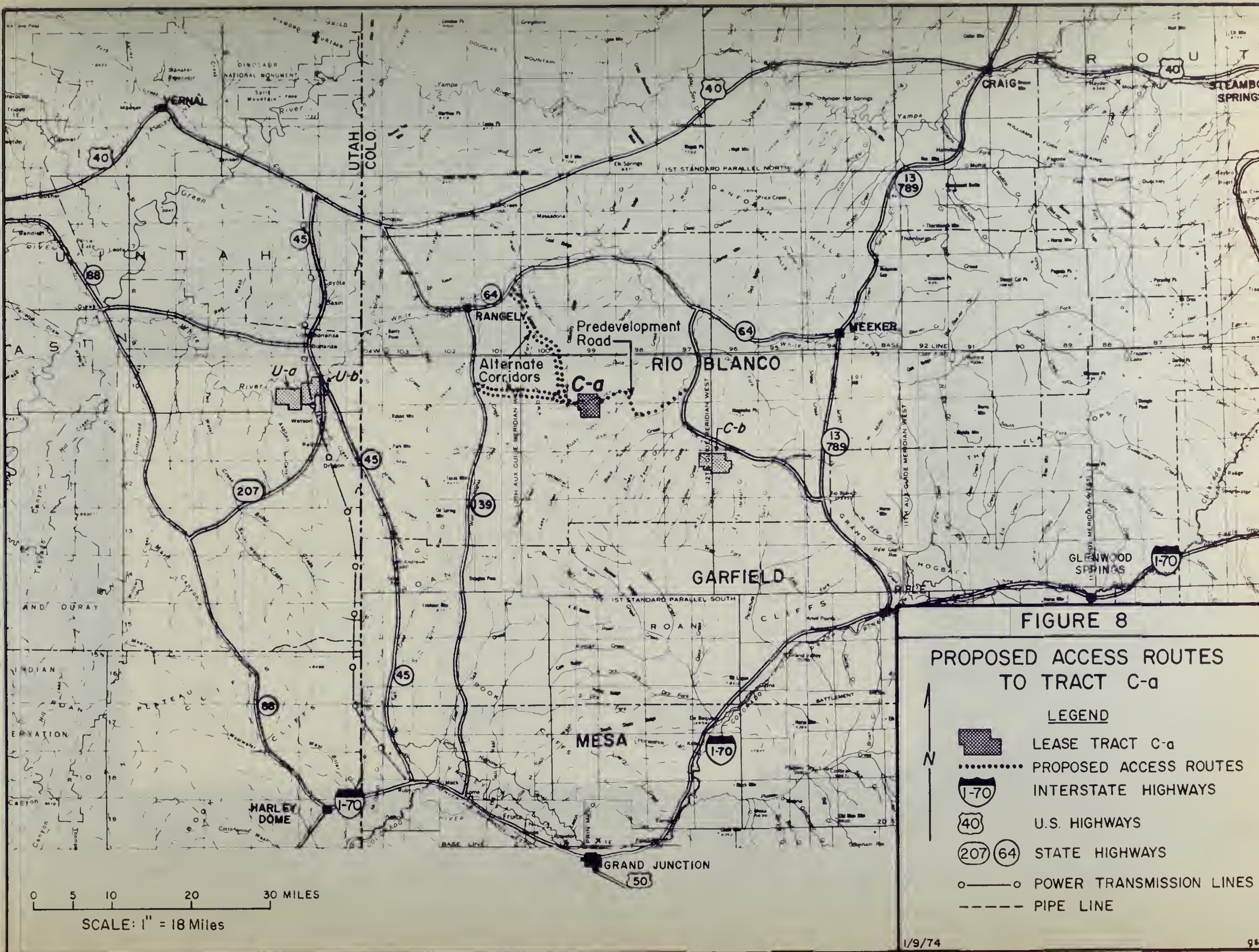


FIGURE 8
PROPOSED ACCESS ROUTES
TO TRACT C-a
LEGEND
LEASE TRACT C-a
PROPOSED ACCESS ROUTES
INTERSTATE HIGHWAYS
U.S. HIGHWAYS
STATE HIGHWAYS
POWER TRANSMISSION LINES
PIPE LINE
N
1/9/74
CRAIG
STEAMBOAT SPRINGS
VERNAL
RANGELY
MEEKER
GLENWOOD SPRINGS
GRAND JUNCTION
HARLEY DOME
RIO BLANCO
GARFIELD
MESA
UTAH
COLO
U T A H
C-a
C-b
U-a
U-b
Predevelopment Road
Alternate Corridors
1ST STANDARD PARALLEL NORTH
1ST STANDARD PARALLEL SOUTH
DINOSAUR NATIONAL MONUMENT
0 5 10 20 30 MILES
SCALE: 1" = 18 Miles

Form 1279–3
(June 1984)

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